Passive Mitigation of Norovirus through Bathroom Design Optimization

BY

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September 2015

Acknowledgements

It is worth taking time to mention the personal side of this research. It was during my daughter's bout with the stomach flu at 18 months of age that prompted my obsession with tamping out this virus. It was, to this new father, an epic battle that lasted nearly a week filled with seemingly constant emesis from a weak, sick little girl that couldn't keep down the slightest amount of food or liquid. Our family ended up visiting the pediatrician as well as the emergency room during this week and the poor girl finally got relief from an anti-nausea medication called Zofran that happens to cost $300 for 3 days worth of doses. Since that week that the entire family got sick but only my daughter faced a protracted illness I have taken an active stance on preventing this nuisance virus that in some cases can be a nightmare.

While struggling to find focus and motivation on my graduate research topic it occurred to me that perhaps this passion I had for combatting the #1 cause of all "food-borne" illnesses was actually a project in disguise. During a time of professional stagnation I crafted a business plan that could provide income as a consultant if needed. The objective would be helping businesses and sports teams avoid being victimized by stomach flu outbreaks and at least reduce the frequency and impact of the illness when it does manage to get by even the best of defenses. It seems most people accept the annual stomach flu as a foregone conclusion and just deal with it. But the amount of complaining I hear on social media, chaos discussed in the news and the economic impact the virus causes, leads me to believe the environment is right for a common sense approach to fighting back. Knowing the virus gives us the ability to make a difference and hopefully with my research and my business we can stop being victims and fight back.

Thus, it is first with much gratitude and love that I dedicate this research to my beautiful and intelligent daughter, Lily. My hope is that she and my adorable and bright son, Joe, will not have week-long battles with this messy virus when they are parents themselves. I also hope to in some way make this world a better place and make a lasting impression on it. It is with my deepest appreciation that I thank my lovely wife for all her patience and support … it wasn't supposed to take this long but life gets in the way sometimes.

Abstract

Hazard Analysis Critical Control Points (HACCP) is one from among many examples of how effective deliberate and thoughtful design can be in improving safety. These safety improvements can be seen in the reduced incidence of illness or injury when consuming foods made in commercial operations employing the fundamentals of HACCP (1). Similarly, the maintenance and cleaning of machinery used in such food production facilities is made much easier when these pieces are designed with the parameters of 3-A Sanitary Standards (2). This is a concept paper about how I believe that similar benefits can be made in public health in the form of fewer, or less severe, outbreaks of food borne illnesses. Given what is known about such illnesses, in the following pages I will attempt to make the case through research and logic (not experimentation and data) that food service establishments can reduce the prevalence of pathogens by adhering to a healthful standard of design in their restrooms. This will result, I believe, in less misery for the infected, reduced reputational damage suffered by affected establishments, and diminished economic impact by the broader economy. Specifically, through analysis of current control measures and their effectiveness, current hand washing statistics, data on the distribution of pathogens responsible for outbreaks, and the current information known about the pathogenicity and means of control for leading vectors it will be clear that further work is required to prove design can improve health.

Table of Contents

    a. Personal
    b. Economic
        i. Care for the ill
        ii. Cleaning
        iii. Lost productivity
        iv. Peak performance—athletes
        v. Fines; lawsuits; reputation
5. Diagnosis
    a. Epidemiology:
        i. Interviews
        ii. Deduction
        iii. Viral identification
6. Control: site-dependent
    a. Education/hygiene
        i. Least invasive
        ii. Least reliable
    b. Reducing at-large virus population
        i. Use of proper sanitizing agents on targeted surfaces
    c. Sick leave for stricken employees
        i. Limited by communication and staffing concerns
    d. Facility design
        i. Bathrooms
    e. Action plan
        i. Rapidly identify Norovirus
        ii. Quarantine
        iii. Equipment and effective chemicals on-hand
7. Disinfectants/sanitizers
    a. Principals of functionality
        i. Probability of rendering viral dose ineffective
    b. Mechanisms by which sanitizers work
        i. Free chlorine
        ii. Singlet oxygen
        iii. Chlorine dioxide
    c. Common sanitizers
    d. Sanitizers and Norovirus
    e. Overuse of sanitizers
8. Discussion
    a. Adapting HACCP
        i. Transmission Analysis, Infection Control (TAIC)
    b. Defining three grades of bathrooms
        i. Good
        ii. Fair

Background

The stomach flu, as it is commonly called, was named after one notorious outbreak that occurred in Norwalk, Ohio in 1968 where approximately 100 children were stricken with violent emesis and diarrhea. Health agencies ruled out with their investigation that a bacterial cause was present. Employing more advanced analysis a viral cause was discovered. This illness is largely misunderstood, under-reported and seldom acknowledged by those who are infected. An unsheathed RNA virus that had been previously unknown but was most likely, in one form or another, causing illnesses and outbreaks for years was determined to be the cause. This virus is extremely contagious and, although symptoms are unpleasant, the illness tends to be self-limiting. Dehydration tends to be the primary long-term complication for individuals that cannot re-establish normal gastrointestinal function within 48 to 72 hours (3, 4). The frequency of outbreaks will not likely subside without raising awareness of its mode of transmission. Additionally, the increasingly crowded environment in which people gather, live and work, and as people's dietary habits change to include more fresh produce also make outbreaks more likely. The economic toll of this virus and its subsequent outbreaks costs businesses millions, if not billions, of dollars in the thousands of outbreaks it causes every year in the United Kingdom alone (5). More recent data suggest the cost is even higher. In 2013 dollars the damage in the United States caused by food-borne pathogens stood at $15.5B (6). This damage can come in many forms but can include lost days due to sick employees, reduced productivity from diminished morale in workers experiencing an outbreak, and from tarnished reputation for certain segments of the hospitality

industry. With the right information, right chemicals, and best practices, as well as the right facility design much of this damage may actually be preventable. Emesis, as an adult, is not just a random occurrence of food poisoning. Data shows that it is very likely of viral origin and each case is a potential outbreak. With information about this virus, businesses can have a plan in place to minimize the likelihood of an outbreak or can at least reduce the scope and impact of one. People get sick and it is not very likely all cases can be prevented, but it is very believable that having the right equipment, chemicals, training, and planning can greatly reduce the number of cases and minimize the magnitude of outbreaks each year.

Literature Review

Norovirus is a member of the Norwalk-like virus family and is an unsheathed, single-stranded RNA virus. According to the Centers for Disease Control's (CDC) information for healthcare professionals, there are currently six known Norovirus genogroups, of which three affect humans—GI, GII and GIV. These three sub-groups contain more than 25 known genotypes, while GII.4 has been linked to the greatest number of Norovirus outbreaks (7).

While anecdotal evidence can be gathered in an interview with a patient regarding symptoms and timing it cannot be confirmed until the presence of a pathogen is confirmed. There are several ways of identifying the vector responsible for an illness in human patients. Over the years much of the actual visualization and analytical examination of the virus and its physical structure has been done using real-time reverse transcriptase-polymerase chain reaction (abbreviated RT-qPCR). The next most used

identification technique is enzyme immunoassay (EIA), which is a method that the United States Food and Drug Administration (FDA) has cleared for use in outbreak analysis but is deemed as of yet too insensitive for use in individual cases (8). Additionally, the power of the electron microscope can be employed, but does not offer any diagnostic advantage over either of the first two methods. It is, however, typically employed in the development of vaccines by developing virus-like particles that resemble the outer structure of a Norovirus without containing its actual RNA (9). Lygocyte Pharmaceuticals is currently using this technology in their vaccine development (10).

Norovirus causes an illness called gastroenteritis. Literally, it translates to the inflammation of the gastrointestinal tract (GIT). The GIT is a 30-plus-foot-long system that begins at the mouth and includes the esophagus, stomach, and the small and large intestines. This is generally a one-directional system of biological plumbing responsible for the uptake of nutrients that seems to have an equator of sorts below the stomach—such that when distressed, the body is able to forcibly expel contents orally from the stomach up (emesis) or the small intestine down (diarrhea). More than inflammation, gastroenteritis includes a wide array of generally painful, but short-lived symptoms including, but not limited to, nausea, cramping, diarrhea, and/or emesis. Specifically, when caused by the Norovirus, gastroenteritis symptoms tend to set in 24 to 48 hours following exposure and last from 12 to 72 hours. Unique to Norovirus, both diarrhea and emesis usually occur (3, 4).

With bacterially caused gastroenteritis emissions tend to come from the stomach or from the large intestine but not both; this has to do with the nature of bacterial

infections. To explain further, in some cases a person ingests a toxin in an improperly stored or adultered food where a bacteria like *Staphylococcus aureus* goes through its latent phase where it produces a toxin in the food prior to human consumption. Consuming this toxin-tainted food is known as a food-borne intoxication and is generally accompanied only by emesis. The other bacterial mode of gastroenteritis is when the bacteria itself is consumed and is able to reproduce and produce toxin inside a victim. Since the latent growth phase takes a number of hours to occur, the toxin is not present in the stomach but highly present in one or both of the intestines and results typically in diarrhea. With the Norovirus, the infection takes place not within the contents of the GIT but within the cells of the GIT itself. This results in a full-scale distress in the GIT causing the victim's body to emit in both directions. This distress tends to end once the contents of the GIT are purged, which usually takes up to three days, but both young and old patients can have protracted cases leading to acute dehydration. Dehydration is the primary severe complication and is responsible for the hospitalizations and deaths associated with Norovirus. Due to the length of the GIT, its circuitous routing, and the often highly viscous contents, victims will shed contagious levels of the active virus in bowel movements for up to two weeks in adults after symptoms resolve. Infants or toddlers may be contagious far longer periods due to their undeveloped intestinal flora and/or immune systems. This is contrary to what most people seem to believe about their own health and is quite possibly the biggest source of outbreak propagation—ignorance.

Contracting the illness requires very few active virus particles—it is believed as few as 18—to cause infection. This is a very low dose and results in a myriad of ways for

new cases to be caused by one initial illness introduced into a population. First, it allows hand-to-surface-to-mouth contact to easily result in new infections. Additionally, the smallest of aerosolized particles generated during a cleaning operation can also result in accidental ingestion and subsequent infection. These particles are called fomites and can also be produced and aerosolized by vacuum cleanup of janitorial products often used to absorb emesis or feces. Many vacuums lack the HEPA filtration required to prevent the internal air circulation from discharging at high velocity the durable viruses that can remain suspended and subsequently spread by air handling equipment or natural air currents. Centralized food preparation is a major cause of food borne outbreaks, Norovirus included. Infected food handlers that return to work while still actively shedding viable virus and do not properly wash hands or follow safe food handling guidelines can become ground zero for massive outbreaks. The virus can be found initially in oysters and when consumed raw, may be responsible for the introduction into human hosts (3, 4).

Norovirus mutates rapidly and has many documented genetic variants. There are at least 25 genotypes and many subgroups (3, 4). The viruses mutate rapidly during their lifecycle and can result in short-lived resistance to re-infection. Single strain re-infection can typically happen after 6 to 12 months have passed. Needless to say, one may be infected with Norovirus many times unlike viruses like chicken pox or Epstein-Barr. There is research currently underway at several major universities, including The Ohio State and North Carolina State, into a possible Norovirus vaccine. One vaccine developed at Baylor College in Texas saw significant resistance (47% reduction of infection rate)

afforded to a control group over a placebo group when given the vaccine via a nasal powder administered in two doses (10). Because of the rapid mutation and general genetic diversity it would seem difficult at the very least for a vaccine to be significantly effective. The researchers admit a few flaws in their study, but nevertheless, a vaccine may eventually be an effective tool in combatting Norovirus infections. Like many viruses, Norovirus cannot be cultured on media, thus research on the virus is difficult and expensive. The feline calcivirus has been used because of its similarity to human Norovirus, but it is not identical, so any findings based on work using the feline variant may not necessarily apply to the human cases (3, 4).

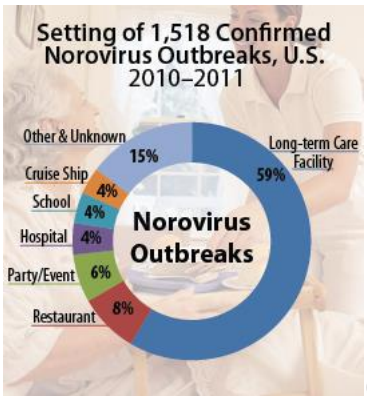
Durability is another aspect of Norovirus that makes it difficult to control. One place Norovirus is not likely to remain viable for extended periods of time is on human skin. This is due to a phenomenon known as competitive exclusion. Human skin is teaming with native and invasive bacteria in a thriving ecosystem and many dangerous pathogens are rendered useless or at least held in check while on your skin. But due to Norovirus's low infectious dose and human tendency to put hands in their mouth, the skin should still be considered an unsafe surface. Where Norovirus can survive for extended periods of time is on hard, sterile surfaces, such as toilets, doorknobs, bathroom floors, sinks, faucets, food prep tables, cutting boards, knives, etc. This is due in part to the fact that the simple virus does not need water to survive. Its protein sheath affords it a degree of protection from many household cleaning agents (except bleach), low concentrations of chlorine, and a wide range of pH and temperature, but it should be kept

in mind that much of this information is collected based on studies conducted using the feline calcivirus (3, 4).

The original case that brought Norovirus into the medical consciousness was a famous outbreak that sickened many students at a school in 1968 in Norwalk, Ohio, hence the name (7). Because the virus follows the fecal-oral route for infection, outbreaks tend to begin with a food preparation setting. Outbreaks are very common in cruise ships, hospitals, assisted living facilities, jails, sports facilities, dormitories, corporate campuses, childcare facilities, etc. Many cruise ships have been returned to port and taken out of circulation for thorough sanitation following massive outbreaks.

Most of these cases boil down to one person not understanding the nature of their illness (ignorance) and the administrators of that location/facility not having a control plan in place. With the number of outbreaks on cruise ships, Norovirus may deserve a name change to the "cruise ship virus." It has ruined vacations and cost the waterborne hospitality industry huge sums of money in refunded fares and work associated with turning a ship around to port due to high numbers of sick patients overwhelming medical bays on-board. While exact numbers are difficult to come by, it is easy to see from social media and news outlets that many cruises are plagued by uncontrolled stomach flu outbreaks annually. The economic harm this illness causes can be found in an acknowledgement of sorts by the industry itself. In the guest rooms the TV networks often broadcast information on Norovirus and how to prevent its spread. There are also abundant sanitizer stations throughout the ships—too bad they are generally using the ineffective alcohol sanitizer.

Not as widely publicized, other common places of stomach flu outbreaks are long-term eldercare facilities, representing 59 percent of outbreaks reported from 2010 to 2011. Hospitals are also on this list but are significantly lower at 4 percent, which is equal to cruise ships and schools. But one must consider the number of people on cruise ships compared to the number in hospitals to remember how widespread the cruise ship problem is. Eldercare facilities tend to be staffed by lesser-trained or even non-medical professionals in some cases. The problem is probably exacerbated further by the compromised immune systems of its elderly residents. This is also troubling because the old are among the most likely to suffer from prolonged periods of illness, re-infection or even death. At 8 percent restaurants, like cruise ships, are common sources of Norovirus outbreaks but even considering the frequency of Americans dining out, the likelihood of being involved in an outbreak by dining out seems remote—see figure 1. All told, approximately half of all foodborne illnesses are caused by Norovirus totaling 19-21MM cases each year in the United States resulting in up to 800 deaths (11).



(Figure 1)

The consequences of being stricken with Norovirus are pretty insignificant for the majority of those infected. The illness and its symptoms are embarrassing and potentially humiliating due to their rapid onset. The illness can be very public when someone

realizes they are about to emesis or have diarrhea while unable to reach a restroom in time. If you happen to suffer the consequences at home it is unlikely one would mention the details of their illness. Herein lies much of the problem: the ignorance of the afflicted leads them to create new cases because they are unaware of how they spread the illness and, that following symptoms subsiding, they are actually in a greater position of likelihood of transmission than when they were actively sick. Instead of cancelling a bridal/baby shower, child's birthday party, family reunion, they proceed. Instead of buying a dish for a potluck or changing the venue to a catered event they soldier on feeling recovered. This leads to many new cases of Norovirus and even outbreaks—in fact, 6% of outbreaks stem from parties or events (11). A little awareness of the facts about Norovirus would prevent nearly all of these cases.

The other non-monetary consequence of Norovirus typically is fatigue and extended lack of appetite or a severe avoidance of the food an individual associates with the illness. Economic damage caused by Norovirus usually involves lost wages suffered from battling an individual's own illness, but can be multiplied if they then have to attend to family members who subsequently fall ill—especially young children. For some young children the illness may lead to hospitalization. In prolonged cases, families may opt for anti-nausea medications, such as Zofran, to allow their children to hold liquids and/or food down. These medications are expensive, costing hundreds of dollars, and may need to be paid out of pocket. If you fall ill during vacation and the entire travelling party becomes ill as well, the money invested in a relaxing vacation may be seen as wasted due to the suffering that was experienced rather than enjoyment.

On a corporate scale, an outbreak causes much more significant economic damage. A large corporation through which an outbreak travels will have suffered potentially hundreds of lost man-hours, deadlines missed, productivity reduced, and travel plans missed or rescheduled. Temporary or contract workers hired for short-term staff coverage may be required in some cases. A study performed in the United Kingdom showed that in their country alone, 11 million working days are lost each year due to stomach illnesses and they attribute Norovirus as one of the largest culprits (5). Hospitality businesses battle with this scale of damage as well, but, more importantly, may suffer immeasurable damage due to the tarnished reputation associated with outbreaks. These companies must not only cover the cost of their own employees' lost time and productivity, but may find themselves caring for their stricken guests or even refunding their fares or payments. It is also not out of the realm of possibility in our litigious society that a class-action lawsuit could be brought if negligence could be blamed for a massive outbreak or other subsequent disaster. Sports teams face a unique situation when battling stomach flu. Should one or more of their multi-million dollar talents be stricken with Norovirus their peak performance may be compromised for several games. And, because these athletes often travel together, outbreaks may quickly spread throughout the team dragging down the performance of the entire team. Depending on the sport or the time of the season, the economic damage of an outbreak may be on the order of millions of dollars. Take for example the 2011 Minnesota Twins' season starting with star catcher, Joe Mauer, being stricken with a "stomach illness" (as it was listed on the team injury report) and how his roommate Justin Morneau shortly

thereafter suffered the same illness. Subsequently, several more position players and pitchers got the same illness. That year, the Twins, with much pre-season promise, suffered one of their worst seasons despite having one of its largest payrolls in team history.

Epidemiology of Norovirus is rather simple. Investigations usually include oral interviews of victims to determine the nature of the symptoms, the events leading up to the illness, and the places people have dined or visited recently. The virulence and short incubation period of the illness actually makes for an easy determination of the cause of an illness. Clusters, groups of two or more related cases of an illness, are very common because of this. Information attained from interviews is often all that is needed to confirm a Norovirus outbreak, and genetic testing of feces or emesis is often not necessary. Some cases may require genetic testing to pinpoint a specific viral strain to make connections, but these tests are extremely expensive. Unless victims have suffered extreme economic or personal hardship having the proof does little good. If such genetic testing is required a stool sample or oral swap following an episode of emesis can collect sufficient genetic information for PCR (polymerase chain reaction) to identify viruses present within hours. ELISA (enzyme-linked immunosorbent assay) can also find a genetic link by identifying antibodies present in a patient's blood and comparing them to those of known strains of Noroviruses (8).

Understanding the virus is the key to reducing the number of outbreaks and amount of suffering associated with this virus. There is more than enough information available on this virus—even contained in this paper—to properly develop a plan in the

event of an outbreak in any setting, as well as to make guided improvements to facilities to make outbreaks less probable even without the willful participation of the general public or employees. Every site, however similar to another, will have sufficient variation to warrant an up-close inspection. That being said, by focusing on the nature of the virus and its transmission, there are two areas that can offer the most bang for the buck so to speak: that would be bathroom and food preparation/consumption areas.

Beginning with lowest-cost options, educational seminars offer the first line of improvement to outbreak prevention. Along with signage and tangible real-world justification designed to make a lasting impression and impress upon the public the important role they play in the spread of illness it may be possible to improve rates of hand washing and illness self-reporting. The hand washing study by Borchgrevink states that modeling and oral instruction increased rates of hand washing from 40 to 56%. However, due to the low level of education, the youth, and the high rates of turnover common among food handler jobs the need for frequent education would be very high, yet the expected benefit should be no better than 40% based on the instruction benefit seen above (12).

Due to the low infectious dose required by Norovirus even modest improvements to reducing the amount of virus on surfaces in a bathroom and on individuals' hands is a likely a more effective and reliable control mechanism. There are several approaches to reducing at-large virus population. Starting in the bathroom, where virus contained in feces of infected or recently infected individuals can easily be moved outward due to human traffic. The durability of virus makes it possible for garments of clothing such as

shoes, pants, sleeves, belts, etc., that come in contact with floors, walls, doors that are in close proximity to a toilet that splashes or otherwise aerosolizes its contents, to be a likely vector for virus into cars, homes or food preparation areas. Just think of how likely it is that within the past 14 days (approximate length of time the Norovirus is capable of surviving on a hard surface) someone in a high-traffic, public bathroom at a retail store, restaurant, or workplace may happen to be someone that is actively shedding Norovirus. During certain times of year it is extremely likely, given typical infection rates, and especially when a site is commonly shared with those that are highly susceptible to Norovirus infections—day cares, grade schools, nursing homes, etc. Recall that the infectiousness of Norovirus also means that very little virus is required to pass an infectious dose onto a child that wrestles with a father who has just arrived home from work or travel and plants a big hug on a leg then toddles back to the table to eat their chicken nuggets with their fingers. Many people still live under the delusion that Purell and other alcohol-based sanitizers are worth using despite their tendency to sting your skin. Recall that due to the Norovirus being unsheathed it is actually, for the most part, immune to alcohol hand sanitizer (3, 4). There are, however, sanitizers that provide free chlorine, which is a more effective agent at neutralizing Norovirus. Among these are those containing benzalkonium chloride (quaternary ammonia family) or hypochlorus acid. Not all sanitizers function against all pathogens and having the right one for the job during an outbreak is critical.

Sanitizers serve as a kill step for control of hand-spread pathogens. Manufacturers usually recommend washing hands thoroughly, when possible, prior to application of any

sanitizing agent to remove filth that may shelter or otherwise interfere with the functionality of the sanitizing chemical. Sanitizers all seek to render viruses, harmful bacteria or other microorganisms left behind following hand washing harmless as a matter of additional reduction in probability that the spread of an illness occurs. Viral infectivity is broken down into a three-phase probability balancing act: $P_{infectivity} = P_{binding} X P_{injection} X P_{replication}$ where P is probability while binding, injection and replication are the phases of viral life essential for the spread of an illness. Reduction of any phase reduces the overall infectivity and the closer any one phase can be brought to zero, regardless of the impact on either of the other two phases, drives the overall probability towards zero as well. Sanitizers commonly utilize free chlorine (FC), singlet oxygen (O_2) or chloride dioxide (ClO_2) as a means of viral inactivation. Wigginton's group showed that on a test virus FC functioned primarily on the disruption of injection and replication but had no effect on binding. O_2 on the other hand functioned somewhat on binding, very little on injection and almost entirely on replication disruption. ClO_2 was unique in that it functioned 100% by disrupting binding and had no effect on the other two phases. It should be mentioned, though, that the team did not use calcivirus as its test pathogen—they used a bacteriophage MS2, which is a single-stranded, RNA-based virus (13). Common sanitizers available to the general public now include several alcohol-free versions in addition to the ubiquitous ethyl-alcohol-based gels and foams. Among those alcohol-free versions active ingredients often include triclosan, benzalkonium chloride, and hypochlorus acid. Sanitizers come in many forms including self-generating foams, aerosolized foams, gels, liquids, sprays and pre-wetted wipes. As was discussed in

previous sections, almost no sanitizer has any effectiveness on Norovirus due to its resilient and tough design (3, 4). As DDT was for insects, sanitizers can be for bacteria and viruses. While extremely effective in some cases, the overuse of sanitizers may someday result in super-bugs that are resistant to sanitizing agents and antibiotics. Triclosan has generally been the sanitizing agent implicated in the creation of antimicrobial-resistant bacteria (13). This point is rendered moot for a couple reasons. One, the use of triclosan in many regions, including the United States and Europe, has now been banned. And two, further studies involving sanitizing agents proven to be more effective in the control of Norovirus including sodium hypochlorite and benzalkonium chloride were shown not to induce enhanced resistance in food-borne bacterial pathogens (14).

Discussion

HACCP (Hazard Analysis Critical Control Points) is a system of food manufacture designed to assure the safe production of food by analyzing the process and formula for vulnerabilities specifically for the food in question (11). Because foods are prone to varying pathogens depending on their pH, water activity, packaging, and origin, not all foods can be treated the same and be expected to be safe. The same holds true for processing. Pasteurization, for example, has a mandated combination of time and temperature assured to reach the desired level of microbiological life reduction and, because of this, it would be critical to assure that the processing reached those parameters at all times. Additionally, those parameters would mean little to nothing in a system of

frozen food. Another factor to consider is that it is cost prohibitive and provides little additional safety assurance to inspect every step of the foods' manufacture. It is then important to limit critical control points to just those steps that ensure consumer safety and for which there is significant vulnerability or risk to foreign matter or pathogenic contamination without further fail safes beyond that point. Safety is always a balancing act. In a perfect world it would be common practice to have unlimited safety checks and sampling points to assure zero chance for injury from consumption, but this would impart significant financial burdens on producers and, subsequently consumers, so compromises are made.

HACCP thusly analyzes each and every formula and process combination to determine first what the hazards are that are unique to a particular food and then second what processing is most likely to deliver safe finished products on a consistent basis. HACCP then goes one step further to determine what parts of a process may introduce their own hazards—e.g., metal detection is often used to scan processed foods for the contamination of finished goods for shavings from worn or failing processing parts that were never part of the food itself. As with many facets of good manufacturing practices sufficient documentation must be kept regarding the planning and system design, but also the ongoing record keeping associated with both passing and failing analysis (1).

It is this careful and thorough analysis that has inspired the inception of Transmission Analysis Infection Control (TAIC) which is an adaptation of HACCP to control the spread of pathogens with a knowledge-based, systematic approach to infection. However, instead of food manufacturing as the arena for its application, TAIC

is applied to places of high human activity like corporate campuses, schools, elder care facilities, hospitals, hospitality industry setting, etc. particularly those that combine food service with extended, close-quarters human interactions. TAIC will, as a result, tend to focus on human-to-human pathogens which are quite often viral in nature and whose manifestations range from respiratory to gastro-intestinal. Also, due to the participation of people in the chain of prevention, significant emphasis will be placed on increasing awareness through educational seminars and printed materials to enhance the awareness of best practices.

HACCP has for years assured the safe delivery of food in an economical manner to consumers despite the many risks inherent to the long-term-storage of foods. A good example is soup, especially canned varieties. Home canning is a somewhat risky proposition due to the anaerobic conditions produced inside the can, thermal processing generally insufficient to kill most active bacteria or deactivate spores, and the poor controls on that processing. In the commercial setting, HACCP would more than likely put a critical control point (CCP) on the thermal processing of canned soup. Specifically, this step, through a combination of time and temperature, guarantees within a certain level of statistical confidence that internal conditions were not only able to kill all active micro-organisms but also vegetative cells and spores of *Clostridium botulinum*, an obligate anaerobe most commonly associated with death from consumption of improperly canned foods. So, of all the things a producer of canned soup would want to do right, the thermal processing step would need to reach and hold the right temperature for the right period of time. Regardless of clean cans, tasty ingredients, preventing rodents or insects

in the broth, etc., the thermal processing is the *most* important, critical step to assuring safe products because killing one's customers is probably the worst thing for business. Now, as was discussed in the preceding sections, Norovirus, despite being extremely common, kills very few people so death is not the primary concern. That does not diminish the importance of taking action. However, action being effective is almost always dependent on cooperation with the humans within the system. Education can be ignored. Bad habits tend to take over. Forgetfulness can derail the best of intentions. But optimal design can make participation easier for those that care and even half-hearted or non-attempts by others less likely to degrade the health of the general population. Like cans of soup in the perfectly designed thermal processing system, humans can be forced into a healthier state with the perfectly designed bathroom. Because Norovirus is present in the feces of ill or recently recovered individuals, and hence their entire perineum, the times when those people place their hands in that region is most likely with use of the bathroom. Thus, hand washing becomes the CCP in TAIC when it comes to Norovirus. There is no time and temperature though in the bathroom (as there is in processing soup) and no simple solution to assuring virus from infected individuals or those recently recovered (yet still contagious) does not leave the bathroom. But there is a way to assure virus loads are significantly reduced outside the restroom thus reducing the likelihood of new infections, and that is to have a bathroom designed in such a way that as many people as possible wash their hands and are able to leave the bathroom with the cleanliness intact. The CCP for Norovirus, according to TAIC, is that as many hands as possible come out of the bathroom with none of the durable Norovirus on them. Factors

such as splashy toilets, complicated faucets, forced- or hot-air hand dryers, inward-swinging and latched doors, poor soap placement, single-ply toilet paper, and poorly placed air handling components all contribute to the spread of Norovirus among a population. Yet these conditions are commonplace in bathrooms today. This is because so many people either do not wash their hands at all or do so insufficiently. It must be assumed that commonly touched surfaces are contaminated if one is interested in keeping their guests, residents, or employees healthy.

I will use a grading system on the following pages to critique numerous public restrooms on the presence of a clean-hands CCP—that is, the ability of people that do wash their hands to easily get out with their hands still clean. To standardize the rating system, a grading sheet was developed and can be found in appendix A. Assuming protocols for hand washing are followed by employees, the presence of a clean-hands CCP will make sure that the fixtures and layout within the bathroom are as conducive to assuring the efficacy of hand washing as an employee returns to their workstation. This means that at the sink itself there are no knobs to turn with hands for shutting water off, no hand-crank paper towel dispensers to actuate, and no doorknobs to turn in order to complete the task of washing hands—see appendix B for fixture quality examples. This may seem redundant at first but given the potential viral and/or bacterial load in the bathroom due to the nature of activities that occur within any and all reductions of the chance for recontamination reduce the likelihood of an outbreak. Take as a comparison a soup HACCP plan. Just because the thermal processing assures sufficient microbial kill producing safe product, and cans come in clean from the supplier having been stored

taking additional precautions, does not mean manufacturers stop there. Usually cans are given a rinse with or without an antibacterial agent to add one more assurance commercial sterility is achieved and products remain safe. Given the severity, frequency, economic damage, and mental anguish associated with food borne infection outbreaks more thought could be put into preventing these outbreaks. Bathrooms are the single most logical place to find opportunities for additional layers of protection.

The job of evaluating bathrooms will then fall on builders, designers, regulators, or inspectors depending on the status of any given bathroom and the regulatory landscape. The most economical approach would have the optimum fixtures chosen during the planning phase but depends on an awareness of the problem and given the seemingly arbitrary fixture choices found in bathrooms it would seem decisions are simply made on an aesthetic basis with little consideration to hygiene. This requires a new level of awareness taught in design and/or building programs. A simpler approach would be to make changes to the building code to enforce a certain healthy standard of fixtures. Perhaps, a new aspect of National Sanitation Foundation (NSF) could allow for a stamp of approval for healthy fixtures and bathroom layouts. Health codes could then be modified for food service establishments to be required to use NSF-approved bathroom fixtures. Making this sort of change would require changes made at the regulatory level and would likely be very difficult and would require a substantial study to be performed. This would require significant funding to assure a thoughtful experimental design that would assure resounding results. Following such changes, inspectors would be required to certify fixtures and designs during the planning phase as

well as coordination with manufacturers to attain the required approval. Inspectors examining existing sites would need to have some criteria to take with them to evaluate bathrooms. I have created a grading sheet that considers all the elements of a bathroom and allows for a quick grade to be awarded to any facility. A simple range would be ideal and would revolve around the presence of a hand-washing CCP.

Grades of good, fair, and poor will be used to rate each bathroom. A good bathroom will make it easy for people to leave with clean hands—if they take the time to wash them properly—and will prevent those that do not wash from exposing active virus to the general population once they leave the facility. A bathroom rated as fair will have an arrangement that makes it cumbersome to reach those goals. A bathroom rated poor will be downright difficult for hand-washing occupants to leave without recontaminating their hands and will promote widespread distribution of fecal contamination from those that do not wash their hands. It is known from the Michigan State study that this is a lot of people (12). All three ratings should be viewed as works-in-progress and that bathroom healthfulness can always be improved. The economic and psychological damage Norovirus puts on people during outbreaks makes it worthwhile to take the steps to improve the condition of poor bathrooms to fair, fair to good, or good to a yet-to-be-defined excellent. The cost is not that significant in many cases and even minor adjustments can make large improvements.

Bathrooms that were evaluated at random will be placed into three categories as it relates to their location: first, commercial properties (restaurants, offices), second, institutional facilities (schools, hospitals, elder-care facilities), and third, hospitality

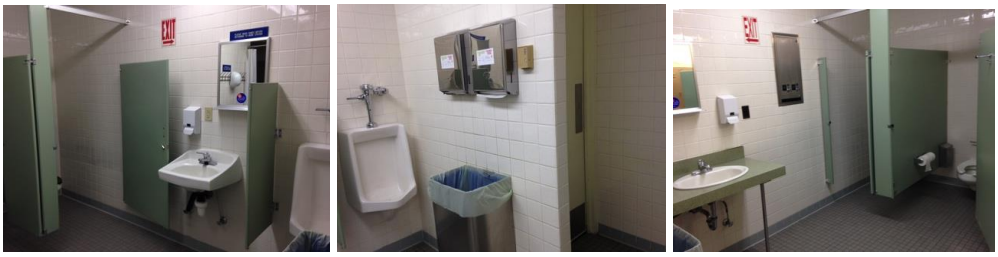
(hotels). All critiques will begin with pictures (showing layout and fixtures) and comments following. The rationale behind these three categories is that they run the gamut of building classifications where people are typically crowded together for extended periods of time. For commercial, significant percentages of time are spent together among employees with or without guest or customer traffic. Commercial will also have a lot of eating occasions within their confines and could offer limited access or emphasis on hand hygiene prior to consumption. Institutional facilities range from schools to long-term care facilities and at times resemble certain commercial traffic patterns but could involve patients living together for years. Finally, hospitality offers a unique combination of transitory population flow along with overnight stays and frequent meal sharing. There is also a high rate of room turnover and one would never know if the sink they set their toothbrush on was, just hours ago, a headrest for a violently ill individual who just recovered from a emesis episode. Hospitality also offers a unique challenge that while the other two categories are somewhat flexible in times of illness, as in those that are sick can stay home or visit the infirmary until fully recovered, in a vacation setting it is highly unlikely the recovered will voluntarily quarantine themselves following an illness because they paid money to be on vacation and, after all, now feel fine making the common mistake that it means they are safe to mix with the other guests.

From each grade level two examples that show the range and a variety of the fixtures that are employed in public restrooms will be highlighted for discussion. Many more bathrooms were evaluated and their photos, grades, and discussion are in appendix A. All imperfections in the design contribute to the statistical probability of a highly

contagious vector, like Norovirus, to wreak havoc on a dense population of people. On the flip side, just about any outbreak can be disrupted by removing even one factor from the chain of events that leads up to an outbreak occurring. Like a set of dominos stacked for a chain reaction, removal of a few key commonly touched areas in a bathroom can be the critical control point for preventing an outbreak that sickens many and could perhaps include sparing the lives of one of the hundreds each year that die of dehydration associated with Norovirus.

Grading Examples:

Good:

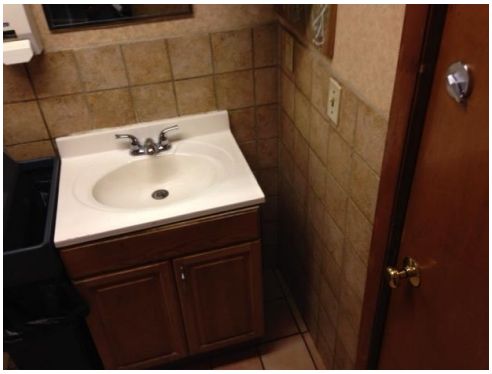
1. 

This is bathroom from a Minneapolis office complex taken on March 4th, 2014 and it scores good but because of its age shows that healthy bathroom design, whether intentional or just coincidence is not a new phenomenon. Without automatic flushers this bathroom is actually somewhat healthier than another restroom in this same building that is equipped with automatic flush sensors but it loses some healthfulness due to the manual faucet. Nevertheless, with the paper towels present and the latchless outward swinging door, this bathroom scores good even though it has high-pressure flushing toilets and only medium height partitions.

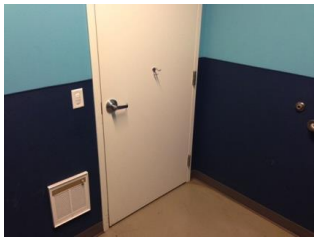
2.  

This bathroom at a popular tourist destination in Ashville, NC was photographed on March 16th, 2014 and is rated as good. The only negative feedback on this facility is the inclusion of automatic flushing sensors on all toilets. The stalls also offer disposable paper barriers for occupants and are equipped with adequately tall partitions but if the sensor triggers a flush while an occupant is in there they would be well advised to hold their breath and make a hasty exit. The sinks are equipped with easy-to-use, single-handled faucets and offer paper towels for drying. There is also a trashcan in very close proximity to the door but a latchless, outward-swinging door is nearly the ideal exit when a door is required and all but eliminates the need for the use of a hand barrier.

Fair:

1.  

This restaurant bathroom was found at one of the many BBQ eateries in Memphis, TN on March 13, 2014 and is rated fair. It does feature paper towels but has a lidded trashcan, high-splash toilet, small-handled-faucet working against it. But the biggest problem here is the inward-swinging door. Not only does it have a small knob that requires a full-hand grip to twist but it also requires a second point of contact before that on a separate deadbolt locking mechanism. Normally, the lock and handle are integrated so that the turning of the doorknob disengages the locking mechanism but this being a family-style establishment some of the fixtures are of household grade. It would be particularly worrisome if this bathroom is used by employees as it would be almost impossible to get out of it with clean hands—unless one practices the use of paper towels as hand-barriers. It would be in the best interest of public health that employees either use a separate bathroom or have been instructed and are required to re-wash hands once returning to the kitchen. One can only hope before they prepare salads or put a straw in a beverage.

2.   

This bathroom was found in a clothing store located in a strip mall in Roseville, MN and receives a rating of fair—although on this particular use it was found to be poor. It has an automatic faucet, paper towels, an easy-to-reach trash receptacle, disposable toilet seat barriers, but all the good is for nothing when the paper towel dispenser is empty as it was on the occasion in which it was photographed. The bathroom features a complicated twist

doorknob on an inward-swinging door and, making matters worse, features an automatic piston closer preventing an occupant from opening the door prior to washing hands paving the way for a hygienic exit. The toilet is a high-splash model which is particularly bad in such a small space. While the stainless steel paper towel dispenser might look nice it leaves no indicator of how full/empty it is—clear plastic would allow employees a simpler visual indicator on the need for restocking ahead of time. This experience demonstrates the power door choice and employee maintenance have on healthfulness. The right door makes paper towels irrelevant.

Poor:

1.  

This bathroom found at a community center in Plymouth, MN on March 4th, 2014 may look clean and is actually quite new, it's actually about as bad as a bathroom can be. It features the unpredictable automatic toilet flushing sensor system on high-pressure toilets. It does have automatic faucets, which eliminate a hand-contact recontamination opportunity, but with an inward-swinging door with a narrow handle it will almost be impossible to get out of this bathroom without recontaminating one's clean hands. Short of using one's own shirt sleeve or tail as a barrier only a risky use of a foot will allow clean hands to exit this bathroom due to the lack of paper towels. The forced air hand

dryer also serves as an aerosolizing mechanism for anyone that washed their hands but failed to get them completely clean of fecal material. Newer is not always better and by simply changing the swing of the door the health factor could easily, and significantly, be improved. What is particularly concerning about this one is the number of children and mothers that use this bathroom. Considering the propensity for young children to suffer the greatest effects of Norovirus I would highly recommend avoiding using this bathroom, particularly during Norovirus peak season.

2.   

This truck stop bathroom was found on March 10th in Evansdale, IA and is rated poor for having a number of negative factors involved in its design. The high-splash automatic toilet without a lid is an awful choice as it forces one to wash their hands in the aerosolized mist of their own waste, and remnants of the occupant before them. This is the rare exception to a paper-towel-equipped bathroom not being graded fair. The large handles on the faucet and presence of paper towels do little to redeem the healthfulness when the trash has a lid and the inward-swinging door has a knob requiring hand contact.

Sites of Norovirus Outbreaks

This next section will apply bathroom analysis to sites where actual Norovirus outbreaks officially occurred as reported by investigations conducted and reports published by the Minnesota Department of Health. Using the criteria demonstrated in the

previous section, the bathrooms of these outbreak sites and many, many more could be analyzed to determine if there is a correlation between poor bathroom design and the initiation and spread of Norovirus. This, however, is beyond the scope of this investigative paper.

Brooklyn Park, MN coffee shop

According to local news sources reported on March 10th, 2014, a coffee shop located in a Brooklyn Park strip-mall was the source of an outbreak of Norovirus involving seven employees and about 20 reported cases among customers, mainly a group of high school girls that regularly made purchases at the store before school. The nature of a coffee shop involves lots of packaged utensils like straws, disposable cups, lids, forks, knives, spoons, plates, etc. on food items that are eaten without further cooking. While coffee is served at a temperature quite often above the 160*F required to kill Norovirus, lids are pressed onto paper cups with the palm of the barista's hand where a poorly-washed hand may readily inoculate with active virus the portion of the lid that goes into the customer's mouth. Hands that have been properly washed have plenty of opportunities to pick up

virus from various hand-to-hand exchanges of money, goods or pleasantries (handshakes, etc.) from individuals that did not properly wash their hands. The percentage of improperly washed hands is far too high to ignore and shift the prevention focus on bathroom design to reduce the viral spread outside of the primary contact average people in the retail, foodservice industry come in contact with feces, thus viruses or other pathogens. The bathrooms in this store are shared between employees and customers and are gender-based, single-occupant facilities. The single toilet bathrooms feature a sink with a single-handled, easy-to-use faucet and provide soap, paper towels and a sign providing instructions on proper hand washing technique. The toilet is a low-splash, non-lidded model and lacks partitions to control any spray that may occur. Making a clean exit after using this bathroom is difficult. The door is an inward-swinging model and has a ranch-style handle that requires an occupant twist to unlock it. To make matters worse, the door has an automatic closure mechanism ruling out the possibility of opening the door before washing hands, which can be done to assure no further contamination risk. Additionally, this bathroom's trashcan has a spring-loaded lid giving another point of contact required following hand washing. Following the outbreak store management interviewed claimed to have made improvements and thoroughly cleaned the store to halt the spread of the outbreak so it is unclear what the bathroom was like prior to the outbreak's occurrence. Regardless of any possible improvements, the bathrooms at this outbreak site still receive a rating of poor.

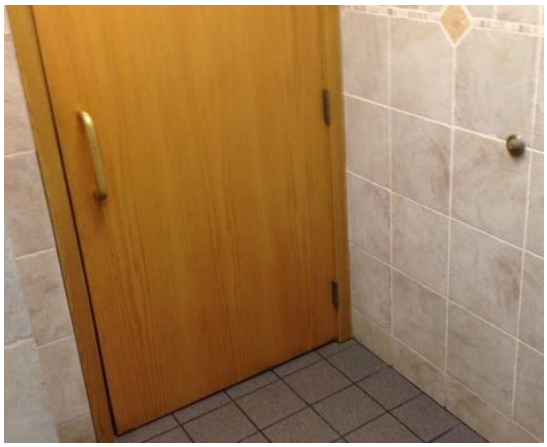
Eden Prairie, MN Mexican quick-casual restaurant



Based upon a report publish by the Minnesota Department of Health, on January 10th, 2013 two separate customer groups at a Mexican burrito restaurant and fell ill shortly thereafter. Three individuals fit the description for gastroenteritis and tested positive for genogroup II Norovirus after submitting stool samples for evaluation. The number of infected individuals was too small to implicate what the vector was that caused the illness. After fielding the complaints, agents went to the restaurant and monitored practices and did not note any critical hygienic violations but did notice a couple instances of bare hand contact on ready-to-eat foods. Agents also interviewed 23 employees for illness history and none reported symptoms before or on the implicated meal date—January 10th. However, one employee reported diarrhea beginning on the morning of January 17th, but this employee was not working on the 10th. The most curious aspect of this case is the fact that only customers reported illnesses leading up to the 10th and while interviews are based on voluntary reporting (and are dependent on cooperation) and Norovirus has been known to sometimes present itself asymptomatically this (customer-only) exclusivity makes it plausible that the presence of virus in the restaurant originated from a customer, perhaps visiting the restroom to attend to an emergency bodily function. This is just speculation but given the nature of the

bathroom and the hand-held nature of the food it is possible that affected customers were seated at a table used by a recently ill individual or used the restroom shortly after an ill or recently ill customer. This becomes somewhat more probable when the bathroom is put under close scrutiny. The bathroom here utilizes a lidless, low-splash toilet in a partitioned stall. It offers a two sinks with large separate hot- and cold-water controls. It does offer paper towels for hand drying but in very close proximity to the sink and trashcan and a significant distance from the door, complicating the disposal of towels used as barriers. The door is a latchless, inward-swinging door with a large pull handle. A conversation with the store manager confirmed that employees share the same bathroom as the customers. Overall, this bathroom is rated as fair but has significant vulnerabilities for the spread of a pathogen due to door choice and paper towel and trashcan placement. While the department's final report found no specific vehicle for transmission, a line of questioning during interviews searching for any use of the bathroom could have narrowed the focus further.

Eden Prairie, MN sports bar



At a restaurant in Eden Prairie, MN on November 4th, 2013 two separate parties that ate at the restaurant and later filed complaints of gastroenteritis to the Minnesota Department of Health and a full investigation ensued. Five total customers met the criteria for the illness based on interviews and two of the three that submitted stool samples tested positive for Norovirus genogroup II. A single food was implicated as being the common element to all illnesses, which was assembled with an uncooked vegetable garnish. Following the complaint, investigators visited the restaurant for an in-depth evaluation and noted several minor issues where handles of utensils were in food pots, a dishwasher (machine) was not sanitizing and incorrect methodology for cooling cooked potatoes were noted. There was, however, full compliance with gloved hands on ready-to-eat foods and proper hand washing was observed. Forty-six employees were interviewed for illness history. While only one incident of an ill employee was filed in the restaurant's logbook interviews revealed four employees were sick in the days leading up to the eating date (November 4th) and two additional employees reported symptoms after. Evaluation of the bathroom revealed yet another mediocre design. The lidless, low-splash toilet is isolated by a partition and the sink features a single-handle, easy-to-use faucet

that makes elbow actuation very easy. The bathroom also offers plenty of paper towels in dual dispensers located near the door. However, the trashcan for the bathroom is located far away from the door and features a swinging lid making disposal of the paper towel barrier, if used, very difficult. Complicating a clean exit further is the latchless, inward-swinging door with a large pull handle. This bathroom is rated fair and is highly suspect as a contributing factor to this outbreak for the following reasons: 1) management confirmed that employees must use this bathroom as it is the only one on-site and 2) clean exits are made difficult due to placement of trashcan and pull-to-exit door. Bathrooms are the most common area for close contact with feces under normal restaurant working conditions and given the prevalence of Norovirus for extended periods of time in the feces of the recently-ill it stands to reason that while several employees are actively ill or recovering the bathroom is an area of high viral concentration. Finally, given the high-rate of inadequate hand-washing by the general public and the hand-held consumption typical of food implicated in this outbreak (hamburger) any patron using the bathroom is subjected to a high level of risk for the contraction of Norovirus.

Arden Hills, MN fast food restaurant

On January 8th, 2012 at a fast food restaurant in Arden Hills, MN, the Minnesota Department of Health determined that an outbreak of genogroup II Norovirus affected three customers from two separate households and three employees were ill prior to and just after the eating occasion in which the customers were infected. In other words an employee was infected and worked while ill, infecting two co-workers and three customers. Too few cases and varied food eaten by the infected customers prevented the isolation of a food-borne vector as a cause. The gender of the first employee is unknown and this is important for one reason: the men's bathroom is rated as good while the women's bathroom is rated as fair. Due to the configuration of the hallway leading to the bathroom, the women's room uses an inward-swinging, latchless door while the men's room features an outward-swinging latchless door. Inside both bathrooms the toilets are high-splash models that have stall partitions but feature an occupancy/motion detector for automatic flushing which, as discussed previously, can lead to occupants being misted by toilet contents if it flushes before the occupant is ready to leave. This is a very serious design choice flaw, especially around Norovirus peak season. Both bathrooms feature

easy-to-use, single-handled faucets and offer paper towels for drying and use as hand barriers. Another flaw in both bathrooms is the use of lidded trashcans, which creates a potential source of hand contamination post-hand-washing allowing virus particles to migrate outward from the bathroom. Again, the men's room rates good, although with reservations due to the automatic-flushing toilet and the lidded garbage can, and the women's room is rated fair, with the same design flaws made worse by the inward-swinging door. It is certainly plausible that bathroom design played a role in this outbreak.

Roseville, MN BBQ restaurant

On April 22nd, 2012 it was determined by the Minnesota Department of Health based on two separate complaints that ten customers tested positive for genogroup II Norovirus after eating at a Roseville, MN BBQ restaurant. Upon interviewing 21 employees, one reported symptoms on April 23rd that worked on the 22nd as a cashier but could not recall if they had served or prepared food. The exact cause of the infection was not identified as a specific food item and the fact that the employee and customers reported illness onset

on the same day leaves the possibility that a customer using the bathroom while ill or still contagious left significant virus on a door or faucet handle. Inspection of the bathroom reveled that the design receives a rating of fair. The very small bathrooms feature a high-splash toilets with stall partitions. The sinks are extremely crowded with a wide-spaced, dual-handled faucet with soap and paper towels placed immediately over the sink making elbow actuation of the water very difficult. Placement of the large, lidded trashcan makes accessing the sink more difficult and adds a potential contamination point post-hand-washing. The door is an inward-swinging, latchless model that makes hygienic exits only possible with the use of a barrier paper towel. It was confirmed by asking management that the employees and customers use the same bathroom. This bathroom receives a rating of fair, with reservations however, due to the number of flaws in addition to the critical violation of the inward-swinging door.

Edina, MN sit-down restaurant

On August, 24th, 2012 five patrons were infected with genogroup II Norovirus by an employee that had worked that day while ill, according to a report produced by the

Minnesota Department of Health. One additional employee became ill after working with the infected employee the day the patrons dined there and were infected although this employee later tested negative for Norovirus and other bacterial food-borne pathogens. Management at the restaurant confirmed that employees and customers share the bathrooms. There are two here and they are both single-occupant, unisex design. Inside each there is a single, high-splash toilet without partitions. The sink features a single-handled, easy-to-use faucet. For hand drying, occupants have the choice to use paper towels or high-velocity hot air. Given the environmentally skewed nature of this restaurant the clientele may be inclined to use the air dryer to spare landfills the refuse of paper towels, which would serve to counteract the hygiene benefits of paper towels. There is also alcohol-based hand sanitizer present. The exit is a spring-loaded, inward-swinging door with an integrated turn and locking handle. The lidless trashcan is small and located under the sink. The final report implicated roasted potatoes as a vector as the first ill employee prepared these earlier in the day while the patrons later ate them. This particular case while the bathroom was rated fair probably was not impacted by bathroom design.

New Brighton, MN sit-down restaurant

On April 22nd, 2013 at a restaurant in New Brighton, MN the Minnesota Department of Health indicates by investigation that there was a transmission of genogroup I Norovirus to patrons from among three separate dining groups. Eight total patrons were confirmed to have had Norovirus from this eating occasion while one employee, a server, had not only experienced symptoms that day but also experienced diarrhea the week before. This server also had a family member ill with similar symptoms the week before. The server volunteered in the interview process to the agent that it was her general practice to scoop chips into baskets for customers with her bare hand. Inspection of the bathroom revealed a facility rated as fair. The bathroom features partitioned, low-splash, lidless toilets and dual sinks with faucets featuring easy-to-use, single-handled controls. The bathrooms also offer paper towels. The shortcomings, however, are that the bathroom exit is a latchless, inward-swinging door and the trashcan, while close to the door, has a spring-loaded lid introducing an additional contact point. This outbreak is not likely to have been caused nor could have been prevented by bathroom design as the interview revealed very strong implications of direct hand contact of ready-to-eat food (scooping of chips)

being the cause. That is not to say that improved hand washing in the bathroom could have prevented the spread of illness. It was also confirmed with management that employees and customers both share the restrooms at this restaurant.

The Minnesota Department of Health kindly provided reports for several years' worth of outbreaks that were investigated and, at their cause, implicated Norovirus. I want to express my deepest gratitude for their assistance in providing advance copies of yet-to-be-published reports. Older outbreak investigation reports can be found at the Minnesota Department of Health's website (16).

Conclusion

Due to the limitations of this researcher including time and funding, this paper will not draw any concrete conclusions about the efficacy of bathroom design in mitigating the spread and severity of Norovirus outbreaks in food service establishments. It is, however, difficult to refute with the use of logic and intuition that treating bathrooms like a CCP will, in all likelihood, reduce the amount of viable Norovirus particles planted by ill or recently ill individuals. If that amount is reduced within the facility, it is less likely that a healthy individual or food preparation worker is exposed. If properly designed, like a 3-A-designed mixing bowl, a bathroom will be easier to clean and less prone to the buildup of filth and pathogens. Additionally, with the right design, users of such an optimally designed bathroom would interact with fixtures such as doors, faucets, and valves in such a way that regardless of how sick or healthy another user was,

the deposition, survival, and transmission of pathogens simply would not happen—or at least would be far less likely to happen.

When troubleshooting an accident, there are various review processes employed by inspectors or analysts to get to the root cause including, but not limited to, why-why analyses or fishbone diagrams. It is quite typical to consider the progress of those involved in a problem travelled through a series of steps like dominos. Following this dominos analogy, by removing one (or more) pieces that normally lead to an outbreak of Norovirus (like having a TAIC-optimized bathroom), a building designer, builder, or engineer would be in a position to make sure that the inevitable contagious person using a bathroom does not lead to the entire stack falling, resulting in a full-blown stomach-flu outbreak—an outbreak that contributes to the millions that get ill, the hundreds that die, the millions of workdays lost, the billions of dollars of productivity wasted, and the humiliation, pain, and suffering this easy-to-control virus causes.

The reason for emphasis on commercial bathrooms in this paper is simple: convenience. Places that suffer more frequent (eldercare or child care facilities) or more publicized (cruise ships) outbreaks are guarded by privacy measures or are geographically difficult for the author to reach. Many arbitrary bathrooms can be found on any given day for evaluation as a pseudo-control group and, with the help of local health officials, reports on actual outbreak sites are also readily available. The purpose of bathrooms is for humans to address their biological needs to excrete waste. Restaurants, hospitality sites, and other commercial properties have a vested interest in these

bathrooms being conducive to good hygiene. This is because food is consumed there, paving the way for human-to-human, foodborne infections.

These facilities often lack separate bathrooms for employees making it necessary for employees to share with the general public. This poses a problem negating one of the biggest tools currently employed by health officials: training. Only the employees get it, not the general public. This is also an area where design that limits the number of surfaces that require touch during and following hand washing would prove very helpful allowing those taking care and/or having the training to motivate proper hand washing are more likely to leave the bathroom with clean hands.

There are other vulnerabilities prevalent in the food industry less common in healthcare and hospitality including language barriers, high employee turnover, low pay, and little to no sick time. These things contribute to a lack of awareness or concern over working while sick or recently following an illness. Like with shared bathrooms, these factors probably result in an increase in viable pathogens including Norovirus in a facility. One factor that would function regardless of training, wages, languages, or health benefits is design. Implementation of healthful design in layout, door opening direction, and fixture selection all function regardless of all other factors.

While its actual toll on an individual is small, Norovirus is a scourge of epic proportions—12-48 hours of stomach pain may not be much to an individual, but multiplied by millions and millions of cases each year the damage is staggering. Some people get it. Funding is in place researching vaccines. This control has its limitations due to the rapidly mutating and highly varied genetic makeup of the Norovirus family.

Development of chemicals to clean surfaces including food prep areas and tools, bathroom fixtures, and even human skin is a continuous process. This approach is also subject to the mutating skills of the virus but also has to contend with the virus' nearly insurmountable defenses. Combine meager progress in any area with education on hand-washing, and maybe some progress will be made; in foodservice, though, turnover is high and pay is low so keeping the entire workforce up-to-date would be prohibitively expensive and time consuming. If however, the equipment used to interact with humans was designed with the virus in mind, like TAIC advises, the opportunities for the virus to jump from the contagious to the healthy are reduced.

It is the findings of this research and the deduction of its conductor that Norovirus in food service settings would be somewhat less likely to create outbreaks if the direction of the door was an outward swing. It would be better yet if the door had no latch or if there was no door at all. Automatic faucets and soap dispensers, as long as they are properly maintained would also create a highly effective CCP of hand washing that would be difficult for non-participants to undo with bad practices. Design of the toilets, flushing mechanisms, and stall walls would have less of an impact because they occur prior to the CCP. Bathrooms equipped as such would earn a rating of good by this grading system and would very likely, without any other intervention, passively reduce the spread of active Norovirus. More research on the topic would be far less costly than vaccine exploration, and would be recommended next steps.

My family has personally suffered the ravages of Norovirus more than I ever wanted, but with careful analysis in how things are handled along the fecal-oral route

(particularly eating; that is when things are introduced to our mouths, but also when in close proximity to a bathroom), our family has successfully defended itself from the seasonal bouts of stomach flu in our schools, workplaces, and even the rare event that one of us ends up sick. Where most families encounter Norovirus and seemingly let it walk through the family infecting one member at a time, workplaces where a large percentage of employees become ill, cruise ships where hundreds of guests become see their vacations ruined, or sports teams watch as one athlete after another contracts this nasty virus our strategy employs tactics designed specifically to work against Norovirus. Our family's techniques require a level of diligence beyond what most could employ as evidenced by the hand-washing study results, but the right combination of gentle sanitizing agents, common sense best practices, and a good bathroom design put food service establishments, nursing homes, schools, hospitality businesses, sports teams, prisons, and hospitals will perhaps make a significant dent in the annual toll Norovirus puts on humankind. Further research would be needed to prove these theories but the impetus is there, the foundation is established, and just taking the next step is required.

Appendices:

- **A)** Bathroom Grading Sheet
- **B)** Bathroom Pictorial Fixture Guide
- **C)** Random Bathroom Evaluations
- **D)** Information on Minnesota Department of Health's outbreak reports

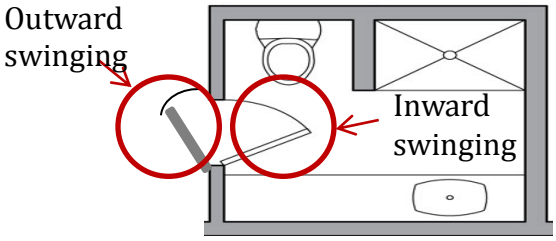
A) Bathroom Grading Sheet

Bathroom Evaluation Form (when options are in bold, please circle one)				
Name/address (street/city/state)				
Type of facility (circle one)	**Convenience Store** **Restaurant** **School** **Grocery Store** **Food Processor**			
Date evaluated (MO/DA/YR)				
Fixture	**X if present**	**Comments**		
Outward swinging door				
Latched/latchless door				
Lock: Integrated or separate		(push button, twist, etc.)		
Inward swinging door				
Latched/latchless				
Lock: Integrated or separate		(push button, twist, etc.)		
No door or door propped open				
Automatic closure mechanism on door				
Double door (airlock-style entry)				
Faucet automatic				
Manual faucet		**Single Temp Control** **Double Temp Control**		
Handle design	N/A	**Finger Twist** **Paddle Quarter Turn**		
Spaciousness (spiggot & bowl--describe)	N/A			
Soap automatic or manual				
Stocked	**YES / NO**			
Back-up inventory		(is there more than one dispenser? YES/NO)		
Paper towel dispenser		**Automatic** **Manual**		

Paper towels stack or roll		Location?
Stocked	**YES / NO**	(is there more than one dispenser? YES/NO)
Air dryer		Brand? Automatic Push-button
Trashcan		(approximate distance from door in feet)
Lidded	**YES / NO**	**Spring Loaded Tilting Food Pedal Hand Lid**
Sanitizer automatic or manual		
Which active chemical?	N/A	
Stocked	**YES / NO**	(is there more than one dispenser? YES/NO)
Toilet upper tank or tankless		
Tankless: automatic or manual flush	N/A	
Upper tank: lidded or un-lidded bowl	N/A	
Stall partitions		
Partition door latched or latchless	N/A	
Slide or twist latch	N/A	
Toilet paper		**Enclosed Open**
Stocked		
Back-up inventory		
Enclosed toilet paper accessibility	N/A	**Easy Restricted Difficult**
Toilet paper quality	N/A	**Single Ply Double Ply Plush**
Does dispenser ration TP?	**YES / NO**	(single folded wipes, limited roll out, etc.)

B) Fixture Pictorial Guide

Door swing



Door latch:

 Latchless  Latched, integrated lock  Latched, separate lock

Door Closer:

 Closes door when not held

Faucet:

 Automatic  Manual, separate controls  Manual, single control

 Manual, requiring finger control (other manual versions allow for elbow actuation)

*Crowded sinks will often have short, stubby spigots or an oddly shaped bowl that makes hand washing a tight fit; spacious sinks make it easy to get hands under water to thoroughly rinse without touching the bowl, spigot or getting splashed by water in bowl.

Soap Dispenser:

 Manual  Automatic (notice the IR sensor)

Paper Towel Dispenser:

Trashcan:

 Lidded/ w pedal  Lidded, spring loaded  Lidded, tilting  Lidless

Sanitizer:

Dispensers are pretty much the same as the soap dispensers but are usually placed nearer to the door; smell contents or read label to identify active chemical (alcohol obvious aroma, triclosan or benzalkonium chloride don't smell and are usually touted as being alcohol-free and usually foam rather than gel)

Toilet:

 Lidded, w/ tank  Lidless, w/ tank

 Lidless, tankless, manual flush  Lidless, tankless, automatic flush

Stall Latch:

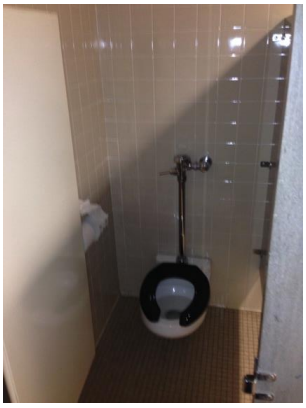
 Sliding, elbow actuatable  Twist

Toilet Paper:

 Uncovered  Covered, inaccessible  Covered, accessible

C) Random Bathroom Evaluations

Institutional:



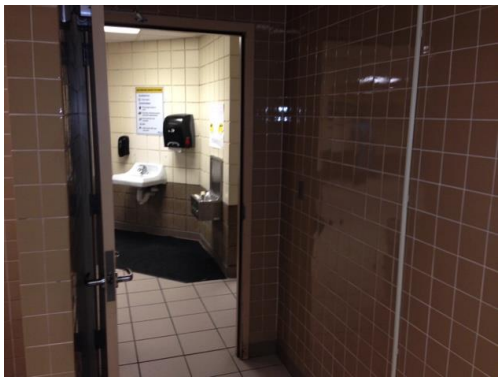
This bathroom is rated fair, with reservations, and was found at a state university building in St. Paul, MN on February 28th, 2014. What makes this bathroom fair is the high-splash toilet that uses significant water flow to prevent clogs but also is likely to aerosolize its contents. This is not, however, the largest problem and the reason for the reservations on the fair rating. There are several factors that contribute to difficulties exiting this bathroom with clean hands and doing so requires some strategy. Notice, first, the door opens inward into a tight space with a low clearance handle requiring hand contact. This could be worked around if one uses a paper towel on their way out act as a barrier between their hand and the handle (there was a garbage can near the door perhaps for that very reason). But the paper towel dispenser presents yet another hand contact point as it is a manual dispenser with a very small crank knob. If one noticed all this before going to the bathroom they could have dispensed paper towels before using the toilet and not worried about the dispenser re-contaminating cleaned hands. The biggest problem is the

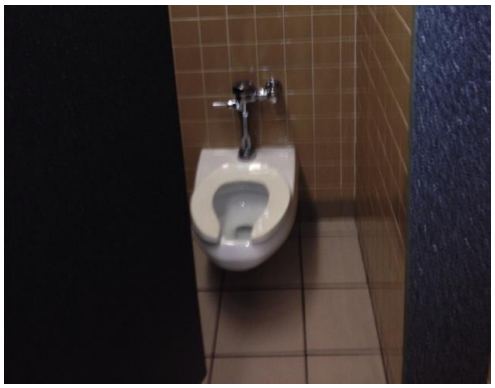
faucet, though and its proximity to the soap dispenser. The faucet has separate quarter turn valves on very small knobs for each hot and cold. The soap dispenser is placed prohibitively close to the knob of the hot water valve making it nearly impossible to use one's elbow to turn the water off after cleaning and somewhat tricky to use a paper-towel-protected hand from bumping the dirty dispenser button for the soap. The one thing that makes this bathroom even somewhat tolerable is that it offers paper towels.

This bathroom was found at a Denver, CO-area, children's health clinic and scores fair. It has low-splash toilets with high stall partitions which contribute to healthfulness, and it provides an easy-to-use, single-lever faucet along with paper towels and a can near the door to conveniently dispose of the paper-towel-as-barrier before exiting. This bathroom also provides sanitizer, however, it is of the alcohol variety so it does little to protect against Norovirus. The door design is the single biggest drawback to this bathroom's overall health score. It has a latch that requires a hand turn and in a stalled bathroom this is a completely unnecessary obstacle to optimum hygiene. The lid on the trash receptacle is not necessary from a functional standpoint and it potentially poses an opportunity for hand contamination as it restricts easy discard of used towels, particularly from the angle

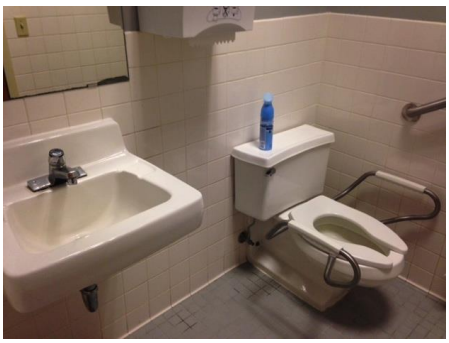
of the door. Facial tissue in a bathroom is ill-advised courtesy as it introduces a temptation to touch one's face before washing hand, especially near the mouth, which is a distinct opportunity for Norovirus infection.

This is a bathroom that scored fair and was found at a Roseville, MN private pre-school. While the school has child-scale bathrooms in the classrooms, this facility is open to teachers, staff, and parents as well as the students. It features very high stall partitions but includes high-splash toilets. The faucet has small, independent temperature control valves but provides touchless paper towel dispenser and a large, open-top garbage can. The exit is just out of view in the sink photo but features an inward-swing with a large D-handle. While this bathroom provides paper towels, which can be used for hand barrier at the door, the lack of a garbage can requires planning on discarding the paper towel after exiting. This added inconvenience is an unnecessary deterrent to a hygienic practice. An interesting note on this bathroom is that with its large vestibule, a simple repositioning of the door to facilitate a saloon-style, dual-swinging door or simply an outward-swinging, latchless door with no impact on the hallway outside the bathroom. A simple, low-cost improvement would be to station an additional trashcan nearer to the door.

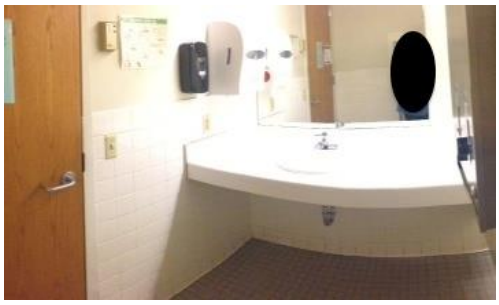




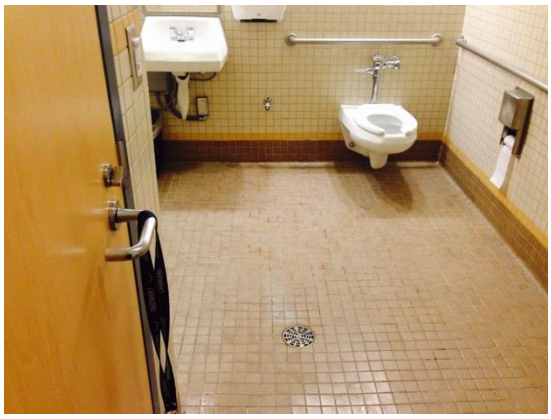
This bathroom, that scored good, was found at a Shoreview, MN elementary school and is intended for children usage based on fixture height. It features high-pressure toilets and stall partitions. This layout is quite common at schools where the sinks are located outside the bathroom so one set of plumbing serves adjacent boys' and girls' rooms. The sinks feature large, easy-to-use faucet levers and, due to the location, provide an easy and healthy exit that is almost guaranteed. It also has the added benefit of peer pressure to wash as teachers may observe student compliance and mixed genders can feed on peer pressure to be clean. This could work well, or it may not happen at all, but the fact that hand-washing results can be preserved easily makes this bathroom one of the healthier designs possible.



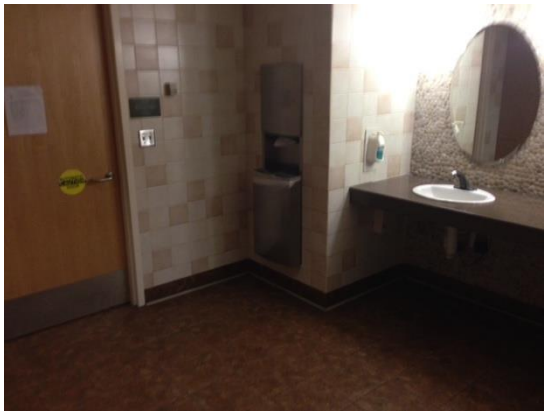
This staff bathroom at a Minneapolis, MN area eldercare facility scores fair. It benefits from a low-splash toilet, simple faucet design and the presence of paper towels. It suffers from the twist-knob, inward-swinging door but with even minor planning a hygienic exit is easy. The unique challenge presented at eldercare facilities is the presence of lift/transfer assist handles which create an additional level of hand contact and require significantly more thorough cleaning, especially during or immediately following a use by infected or recently recovered individuals.

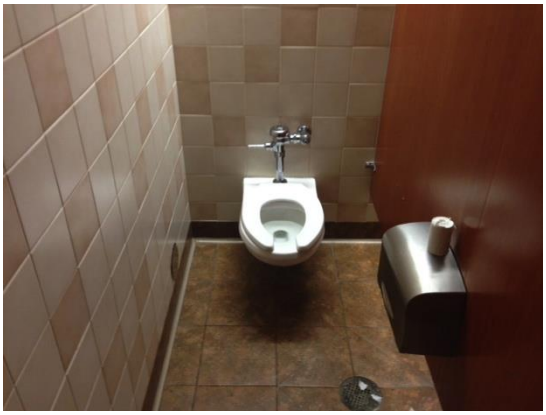


This is a public restroom at the same Minneapolis, MN eldercare facility as above and scores fair. It has the same low-splash toilets, this time with stall partitions. Again it makes the mistake of having a turn latch, inward-swinging door but at least provides paper towels to serve as hygienic hand barriers.



This bathroom was found in a San Diego, CA public school on March 7th, 2014 and is intended for staff only. It received a score of poor. As a single-user stall that has a high-splash toilet and no stall partition nor lid, it would be very unfortunate to enter the bathroom following use by a recently-ill individual. It also has a cramped sink with two-lever faucet with very small control levers, which makes elbow actuation nearly impossible. It also has a very unhealthful exit as it has a small, latched and locking door giving multiple points for soiled hand contact. As if this bathroom couldn't get any worse, it includes a forced-air hand dryer which leaves no clean way out short of a physically risky use of a foot or the highly unusual solution of using one's own shirt as a make-shift barrier—if that were to be a solution during peak season, for the rest of the day the individual would have to be wary of that spot on the shirt and make no contact with it during mealtime.





This bathroom found at a Minneapolis, MN area hospital on March 6th, 2014 scored good and is open to patients, visitors and staff alike. It features high stall partitions to help control aerosolization from the high-splash toilets. It does just about everything right for a clean exit: it has touchless faucets, paper towels, a trashcan close to the door and an outward-swinging door. The only drawback on this bathroom's exit is the latched doorway but for the health-minded individuals, it's easy to use one's elbow or a barrier paper towel. The doorknob is entirely unnecessary in this bathroom and should be removed.

This bathroom was found on March 6th, 2014 at the same Minneapolis, MN area hospital but is limited to staff only. It receives a score of fair. It is approximately 16 square feet and features a high-splash toilet making it a horrible risk for aerosolized transmission and propagation of Norovirus. The faucet also contributes to the unhealthy rating with separate controls but the size of the levers would make elbow-actuation easier. The presence of paper towels and a large trash can help those with a well-planned exit

strategy make the most healthful exit possible; this however represents a very slim minority of people.

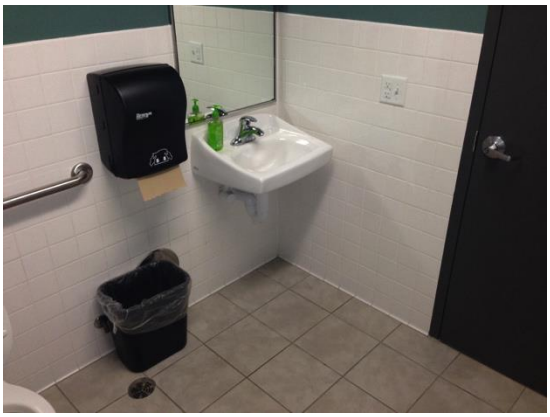
This is yet another staff bathroom at the Minneapolis, MN hospital March 8th, 2014 and it receives a score of fair. It is another very cramped space with a high-splash toilet and an inward-swinging door with a twist latch. The faucet has large handles that would be easily shut off with elbows but has separate controls for hot and cold which doubles the points of contact. It does offer occupants paper towels but the garbage can is out of reach from the door.

This is another patient bathroom from the same Minneapolis, MN hospital taken on March 8th, 2014 and it receives a score of fair. The supply of paper towels, large faucet handles and an outward swinging door are benefits that outweigh the detriment of a high-splash toilet in a cramped space. It is not an ideal bathroom but a small amount of thinking can make for a healthful exit, which would be important if one is an admitted patient, family member or caregiver thereof.

This is another bathroom showing another slightly different variation on the patient layout at the Minneapolis, MN area hospital photographed on March 9th, 2014 and it receives the score of fair. Once again, there is an outward-swinging door, paper towels and a garbage can very near the door along with a large-handled faucet to facilitate healthful exits. With the high-splash toilet it would be wise to delay flushing the toilet until once the door is opened and an occupant could make a quick exit. In this flush routine it is advised to use a foot or a barrier-equipped hand to actuate the flush lever because touching it last makes the healthfulness dependent on the cleanliness of a knob over a splashing toilet.

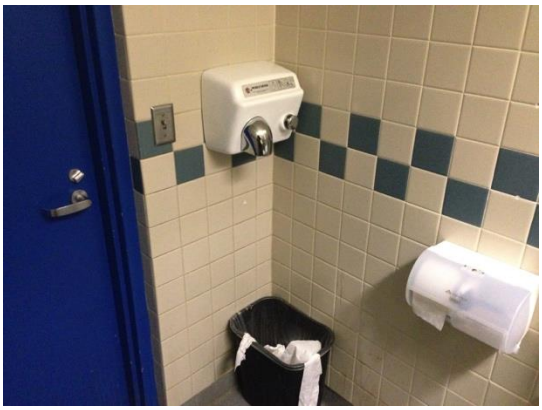
This bathroom was photographed on March 17th, 2014 in St. Paul, MN at a dentist office and is open to staff and patients alike—it receives a score of fair. It has high-splash toilets and stall partitions. The sink area has touchless, automatic faucets and offers a stack of paper towels for hand drying. These paper towels can, however, be contaminated with droplets of water shaken from other occupants' hands so it would be unwise to use one to wipe face. The inward-swinging, latchless door with large easy-to-grip handle requires a paper towel barrier for clean exit but is easy enough to exit cleanly despite the trashcan having a foot-actuated lid. It just means someone with impaired mobility (wheelchair, walker, unsteady balance) would be at a disadvantage to manage the door and a proper disposal of their barrier.

Commercial:

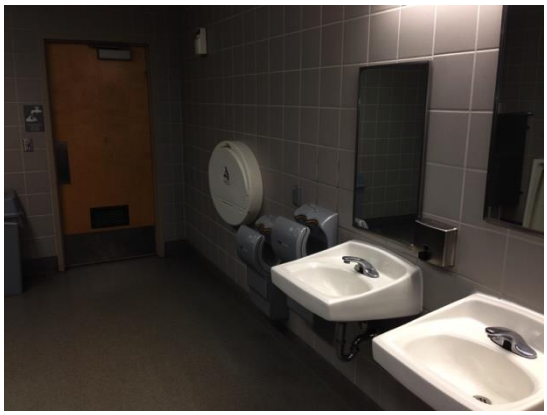


This bathroom receives a score of fair. It was found at a local youth dance school in Roseville MN on Saturday, March 1st, 2014. It features an inward-swinging door but this time it has a finger-twist locking mechanism and a ranch-style doorknob requiring hand contact. If the paper towel dispenser runs out of towels this is a filth-trap during Norovirus peak season. The toilet is a low-pressure flush, not likely to spray as much as high-pressure, tankless toilets but its proximity to the paper towels and the lack of a stall partition serve to degrade the health factor of this bathroom. The faucet does provide conveniently-placed soap and a large, single-handled control valve making elbow actuation easy but this does little to help those that are already only haphazardly washing their hands as the doorknob will most surely re-contaminate those that do not habitually use a paper towel barrier to use doorknobs.

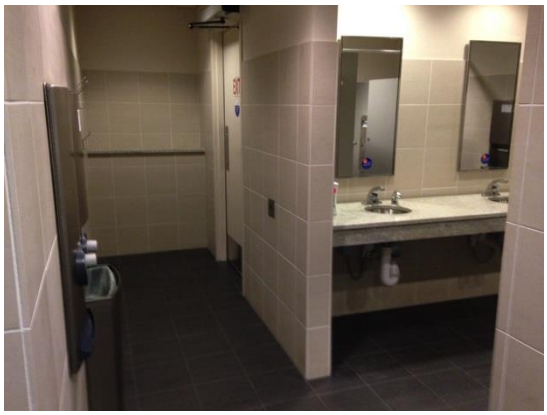
This bathroom, scoring fair, is located at a small office complex in Eden Prairie, MN and the photographs were taken on March 3rd, 2014. Again high-pressure toilets are paired with stall partitions. Located just above the stalls is a single HVAC vent blowing conditioned air into the bathroom, which supplies movement to any aerosolized matter projected outward by the toilet. The sink area has two faucets that have separate hot- and cold-water controls but are of sufficient design and placement to enable elbow actuation leaving clean hands clean upon completion of hand washing. The door reduces the health factor due to its inward swing but it does have a large handle and is in close proximity to the paper towels and trash receptacle should a concerned individual choose to use a paper towel as a barrier. The small-volume trash can right under the paper towel dispenser results in the potential for direct contact with the clean towels or hands with its contents. This bathroom is on the better side of poor but the only way out with clean hands is use of a paper towel barrier (and this depends on there being paper towels) so the fair rating overall stays.



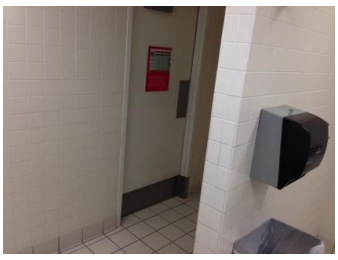
This bathroom scored poor. It is in a community center in Shoreview, MN and was taken on March 3rd, 2014. Factors contributing to this bathroom's unhealthy rating are that it is extremely cramped and features a toilet with high pressure flushing in close proximity to the sink. The faucet does have a large single handle making control very easy but it does not matter when every flush of the toilet is very likely spraying fecal matter on the sink and soap dispenser. It also lacks paper towels and features a forced-air hand dryer, which eliminates the barrier option for flushing, faucet operation or door opening. One would almost have to hold their breath to use this bathroom in a healthful manner. The one redeeming characteristic here is the fact that it has an outward swinging door. It is still possible to exit this bathroom safely but takes very careful planning and delaying flushing the toilet until after you've opened the door and are prepared to leave. It would also be critical that you did not use this facility after someone who was actively shedding Norovirus in their feces or had a emesis episode, but this is almost entirely dependent on luck.



This bathroom scored good with some minor reservations and was found at a club store in Eden Prairie, MN on March 4th, 2014. It does just about everything right except for the high-velocity, forced-air hand dryers which can aerosolize virus-containing fecal contaminants off inadequately dried hands. The toilets feature high-pressure flush but provide a sanitary barrier for occupants and high stall partitions to reduce the sprayed virus potential. Sinks score very well for providing hands-free sensors, which eliminate a touch point for those not familiar with elbow use for shutting water off post-washing. The biggest benefit to the health factor to this bathroom is the outward swinging door without a latching mechanism. The bathroom is also quite large which allows for greater dilution with clean air any aerosolized virus from the hand dryers or toilets which should contribute to a reduced spread of active virus.

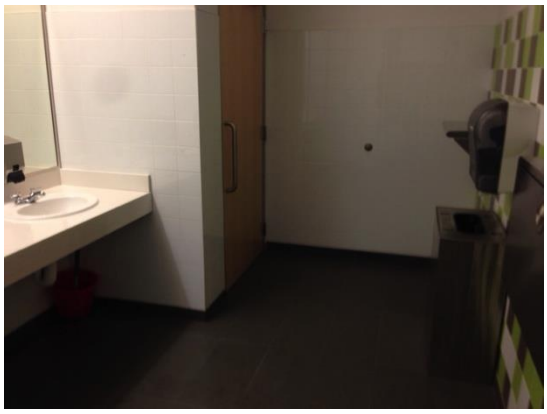


This bathroom is located at a Minneapolis office complex housing roughly 300 people and is one of many bathrooms on-site. It scores good with a minor reservation due to the automatic flush toilets which can prematurely flush, aerosolizing an occupant, potentially with virus due to the unpredictable nature of the sensors. Faucets are also touch free which promotes a clean exit following hand-washing and the paper towels add a mechanical scrubbing to the cleaning process to further reduce residual virus on hands without even being needed for a clean exit because of the outward-swinging, latchless door. This bathroom was a recent renovation and scores very well from a health standpoint.



This bathroom was found at a major discount retailer in Eden Prairie, MN on March 4th, 2014 and scores good. Despite having high-pressure, splashy toilets, it provides users with paper towels, easy-to-use faucets, several soap dispensers (which reduces the

likelihood the bathroom will be completely out of soap), and, most importantly, an outward-swinging, latchless door. High partitions are present to provide decent toilet-spray control and this bathroom even provides multiple paper towel dispensers reducing the chances of a complete outage.

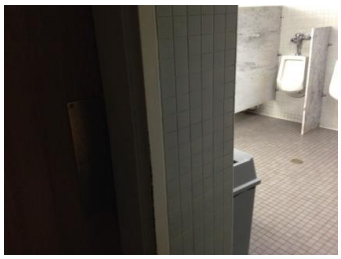


This bathroom was found at a Ramsey County (MN) public library branch and scored fair. It features high-pressure toilets with stall partitions. It has dual sinks that have small, separate controls for hot and cold water. While it provides paper towels and a trashcan somewhat close to the door, it is just outside of easy reach for a discard of the barrier from the doorway. It features a shelf for convenient temporary storage of books or bags, but in addition to opening one up to being the victim of theft, poor hand washing by most makes this a potential hotspot for fecal and viral contamination of goods that may accompany occupants home. Keeping this in mind, books are often read at home, and many folks use mouth-moistened fingers to turn pages. This creates a chain of events that could lead to viral infection. It may be a stretch, but is nevertheless possible due to the durability of the Norovirus and the predictably poor hygiene of the general public.



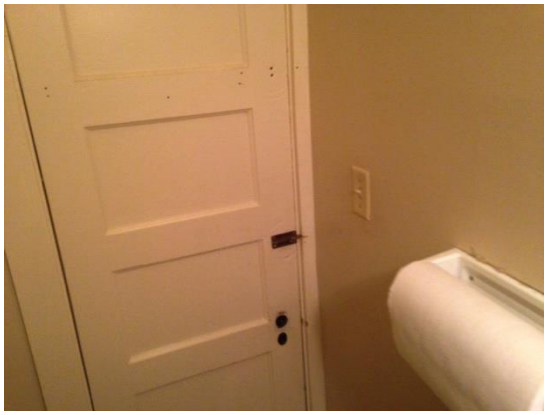
This bathroom was located at a mall restaurant in Nashville, TN on March 14th, 2014 and is rated fair. It has high-splash, automatic flushing toilets but does feature partitions to help control the spray. The automatic flush feature while it eliminates a contact opportunity with a potentially filthy surface they flush when the occupant gets up or, at times, when they shift their seating position before finishing. This design flaw can be corrected by installing a delay of some period of time on the occupancy/motion-detecting flush. While the toilets are a poor-hygiene application of automatic plumbing fixtures, the sink has two applications of it that promote health. The faucet and soap both being automatic provide the hand washing necessities while eliminating the recontamination potential. The exit is inward-swinging but features a large pull handle and the provided paper towels make a healthful exit fairly straightforward.





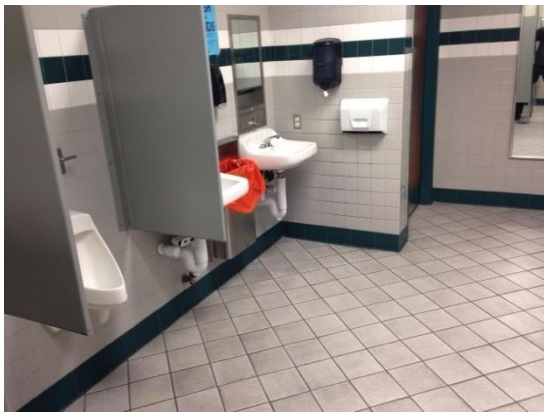
This bathroom at another popular tourist destination in Ashville, NC (one that happens to be themed on the production and consumption of food) was photographed on March 16th,

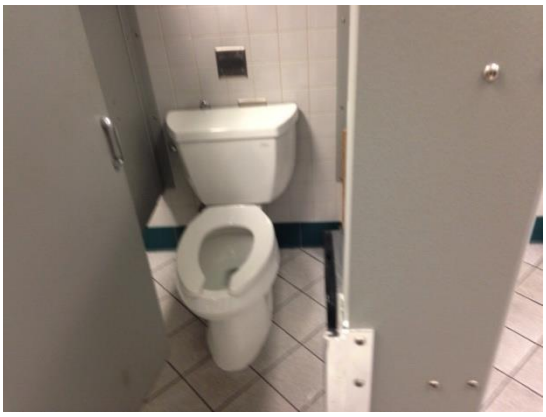
2014 and is rated as good. The high-splash toilets are manually flushed and guarded by partitions. The sinks feature single-handled faucets and offer paper towels for drying. The trashcan is placed conveniently by the exit, which is another latchless, outward-swinging door, which serves the hygienically-minded users very well. It should be noted that this bathroom, due to its exit orientation, would be well served by simply removing the door for even further improvements to the already good design.



This bathroom was photographed in Edenton, NC on March 17th, 2014 at a family-owned restaurant and receives the score of fair. It is a cramped space that fortunately does not use a high-splash toilet. The sink is a bit cramped and has separate controls for hot and cold water. The soap dispenser is also tippy and not on a flat, level surface so it may require two hands at times to get soap without knocking it to the ground. The bathroom does offer paper towel that are open to be cross-contaminated with toilet aerosolization or water from occupants' hands that were improperly washed. The door is an inward swinging model that hardly seems practical given the cramped quarters but has a tiny knob and lock mechanism that would make using a barrier very difficult.

This bathroom was photographed in Cape Hatteras, NC on March 18th, 2014 and receives a score of poor. It features partitions and simple, single-handled faucets which are the only two things this bathroom does right from a health perspective. The flush mechanism on the high-splash toilets is automatic based on occupancy sensors. Hand drying is performed by hot air blower, which means there is no provided barrier for use on the inward-swinging, latchless door.





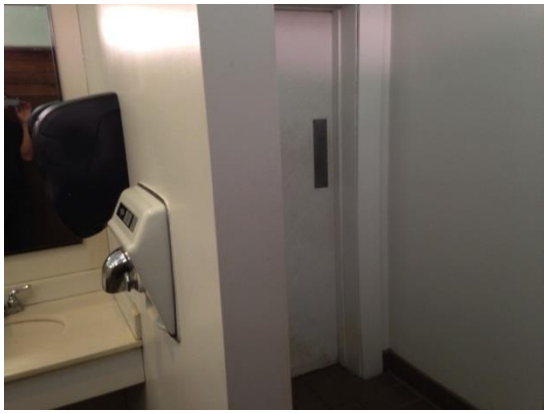
This bathroom was found at a roadside rest stop in North Carolina on March 18th, 2014 and receives a score of good. The low-splash toilets have partitions, which is nearly as

good of a combination as one could hope for in a toilet. The sink features a touchless sensor, which is also optimal for healthfulness. For drying this bathroom actually offers two options: hot air (bad) but also paper towels (good). The forced air at least aims downward and is lower-velocity than some blade-type dryers which are newer to the market—high-velocity air, like high-pressure air/water in plant equipment clean-ups tend aerosolize contaminants so while environmentally friendly these high-velocity models are a potential vector for the spread of fecal-born illnesses. The final thing this bathroom does right is at the door—a latchless, outward-swinging door.

This bathroom was found on March 19th, 2014 in Maplewood, MN at an indoor playground that does not serve food and is rated as fair. It has a low-splash toilet, which is desirable for a small bathroom. The sink is equipped with an easy-to-use, single-handled faucet. It also offers paper towels (not pictured) for use as a barrier to compensate for the latched, inward-swinging door but the garbage can has a flip-style lid making disposal of the towel somewhat more challenging as disposing of the towel requires that one open the door first, then return in to the interior of the bathroom, next to

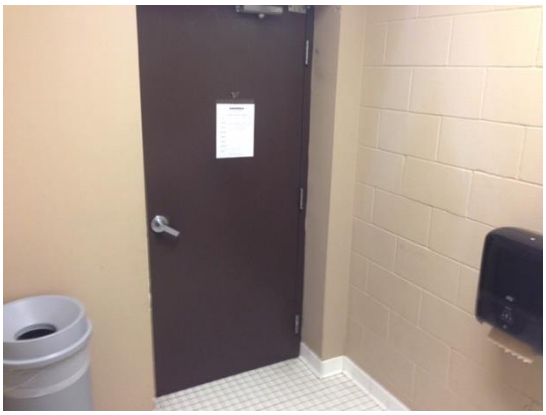
the toilet and make contact with a contaminated surface—only careful disposal of the barrier will maintain hand cleanliness.

This bathroom was found on March 21st, 2014 at one of several museums on Jekyll Island, GA and is rated as poor. The toilet is a low-splash model and this is about the only thing this bathroom does right. The faucet is controlled by a two-handled faucet, with very small controls, making elbow actuation difficult. It also provides an air-dryer for hand drying instead of paper towels which leaves no barriers to cope with the latched, inward-swinging door—among the worst possible designs possible.

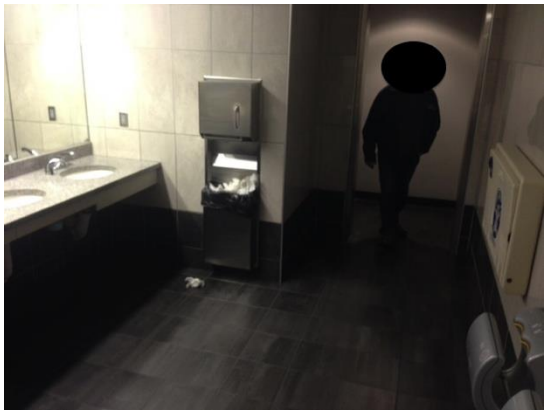


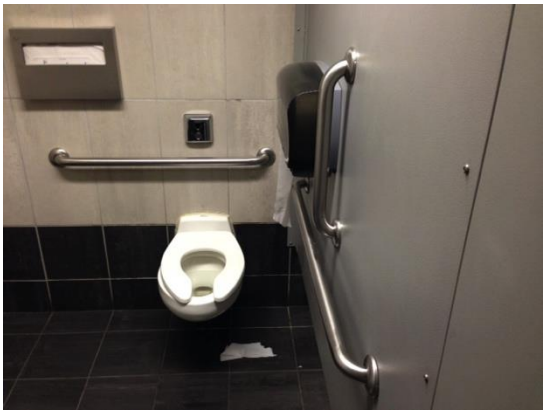
This is a second museum bathroom located on Jekyll Island, GA but received a rating of good. This bathroom has high-splash toilets guarded by stall partitions. The sink area has small-, dual-handled faucets that make elbow actuation difficult but not only does this bathroom provide the hot-air hand drying optiong but it also offers paper towels to use as a barrier on the faucet knobs. The exit is around the corner and lacks a trashcan nearby but elbow opening is very easy as the door is outward-swinging and latchless.

This bathroom was photographed at a corporate fitness center in the men's locker-room on March 24th, 2014 and is rated fair. It is equipped with a low-splash toilet. The faucet has independent hot and cold water controls on knobs that are difficult to control with elbows but the presence of paper towels can be used as barriers for the faucet, toilet and inward-swinging door use. The paper towels are left in the open for potential contamination by water splashing off poorly-washed hands of other users. There are also facial tissues provided and the bathroom is an unwise place to promote touching one's face due to the prevalence of pathogens.



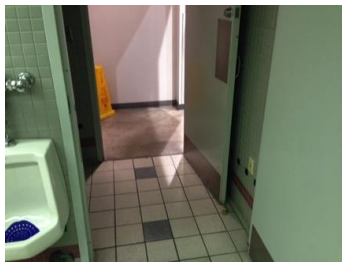
This bathroom was photographed on March 25th, 2014 at a Roseville, MN mall and is rated as fair. The high-splash toilet lacks a lid nor does it offer partitions to control spray in a cramped bathroom floor plan making for an unhealthful design. Timing can get around this and there are paper towels provided for use as barriers for sink and door actuation negating some of the negatives associated with inward-swinging doors. The trashcan is also conveniently placed near the door for disposal of barrier towels upon leaving. However, due to the spring-loaded closure on the door should this bathroom be out of paper towels an occupant would be almost unable to leave this bathroom with clean hands.





This bathroom was photographed on March 26th, 2014 at a Minnesota airport and is rated as good. This one benefits from averaging because it does a number of things perfectly while including some of the worst features for healthfulness. On the plus side, it lacks a door and uses serpentine exit to provide privacy eliminating the departure risk of recontamination from a contaminated doorknob. It also features touchless automatic faucets. It provides paper towels for drying but includes the ultra-high-velocity Dyson forced-air hand dryers that could potentially aerosolize virus particles from poorly washed hands of the recently ill. The toilets, while the provide sanitary paper barriers and tall partitions for spray control, they are high-splash models with automatic sensors which can lead to an ill-timed triggering of the flush. Overall, a good design but money could have been saved and healthfulness improved with smarter design.



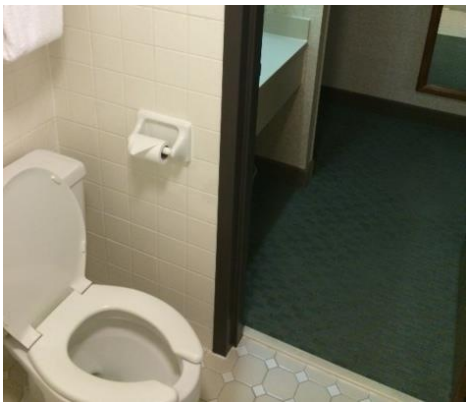


This bathroom was photographed on March 27th, 2014 at a Las Vegas, NV exposition hall and is rated as good. The toilets are high-splash models with tall partitions and provide occupants with paper seat barriers for peace of mind. The sinks are equipped with touchless, automatic faucets and offer paper towels for hand drying. The housekeeping staff had both doors propped open for easy, rapid and healthful exits at both ends of the restroom area which prevents the door handle from recontaminating washed hands. Wherever possible, this provides an extremely cost effective solution to

inward-swinging doors when layout allows sufficient privacy with doors left open. If an occupant encountered these doors closed the provision of paper towels would allow an extra measure of healthfulness by providing a barrier option.

Hospitality:

This bathroom was found in a hotel at a popular tourist attraction in Wisconsin and it scores fair. It is undersized for guest use and puts a toilet dangerously close to the sink where oral hygiene products (e.g. toothbrushes) are often kept. Despite being lidded and low-splash, the toilet is very near the sink and there is no guarantee the lid will be closed to prevent splashing. The garbage can is undersized for a family of 3-5 that may stay in a double room. The faucet features separate small handles for hot- and cold-water control and the entry door swings inward with a round twist knob. In the event that one family member contracts Norovirus this bathroom is poorly equipped to deal with increased usage and is of insufficient design/layout to make it likely anyone else in the family will escape infection.



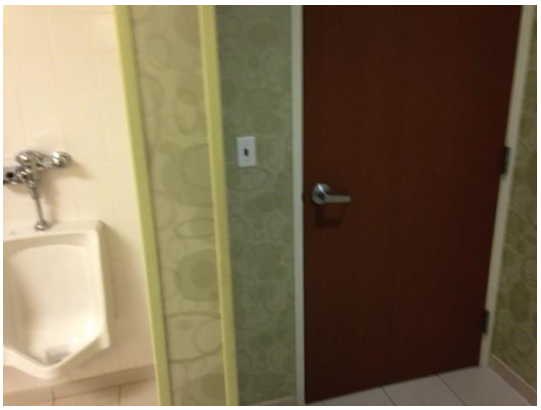
This guest room bathroom at a St. Louis, MO hotel photographed on March 8th, 2014 receives a score of good. Working in its favor is a low-splash toilet with a closable lid and a sink area removed from the toilet area. This separation, as is the case in the elementary school restrooms means that occupants get the chore of opening an exit door completed before washing their hands meaning one less chance for recontamination. If, however, this room was shared by more than one occupant and one of who them was actively shedding virus, it would be important to utilize the toilet lid or relocate the clean towels should the unlikely toilet splash make it sufficiently high to sully the fresh linens. This is an unlikely scenario but, in theory, possible.

This bathroom is a public restroom at the same St. Louis, MO area hotel and it receives a score of fair. The toilet is a low splash model and the sink is touchless but the inward-swinging door combined with the lidded trashcan makes for a tricky exit. The simplest fix is to remove the lid on the trashcan or replace the unit with a lidless model. Other than controlling potential odors the lid serves no purpose but to complicate the use of paper towel barriers used to turn the doorknob upon completion. The small receptacle in the paper towel dispenser is an option, as is a can outside the bathroom, but each present enough limitations that the score of good is not possible. For one thing, discarded paper towels can sully the fresh paper towel for the next occupant and, for another, it is of very limited capacity and may not always be an option. This bathroom features a sanitary measure not often found and that is disposable seat covers. The efficacy of these has not been measured for the purposes of the grading but paper is not generally considered a virus barrier so it may be more for piece of mind rather than actual healthfulness.

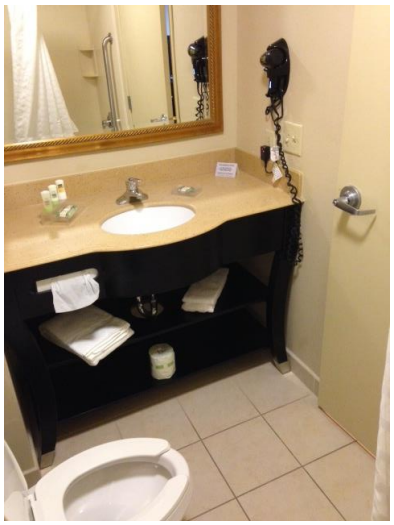
This guestroom bathroom was found and photographed in Peoria, IL on March 10th, 2014 and received a score of good. It features a lidded, low-splash toilet and a separate hand-

washing area outside the inward-swinging door neutralizing the health detriment of that style of door. Like many other bathrooms of this layout, however, the extra towel storage is right above the toilet so some caution is advised if staying with someone who has been ill recently. The faucet has a single control lever that makes elbow actuation quite easy giving occupants an easy task of completing hand washing with cleanliness intact.

This hotel bathroom in Louisville, KY was found in a guestroom on March 12, 2014 and is rated fair. In a small guestroom like the one at this hotel, if concerned about viral contamination, it would be easy to plan a healthful exit despite the inward-swinging door with a twist knob. The easy-to-use faucet and low-splash, lidded toilet make for a relatively germ free exit, if an occupant flushes the closed toilet, opens the door first and then washes their hands. There are no paper towels as there usually are only linens in guestrooms but there are facial tissues if a barrier is needed.

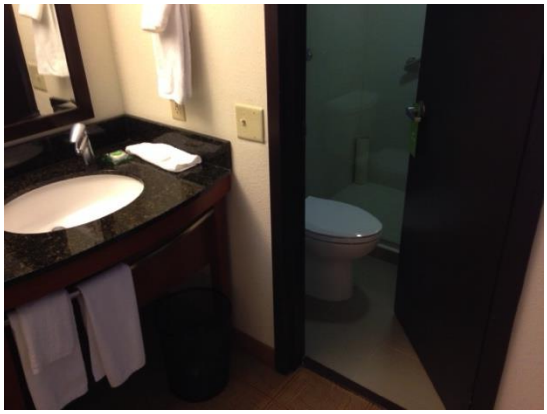


This is a men's restroom at the lobby of the same Louisville, KY hotel where the guestroom facility was taken on March 12, 2014 and receives a score of fair. Not seen in the pictures are high-splash toilets featuring partitions. The door swings inward and has a turning latch for security but the presence of paper towels and easy-to-use faucets make it less difficult to make a healthful exit with only minor planning. The only other negative characteristic of this bathroom is the lack of a convenient trash receptacle near the door for barrier disposal but hotel lobbies generally have trashcans throughout.



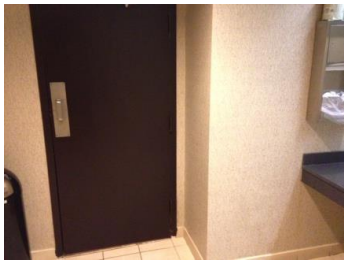
This guestroom bathroom at a hotel in Bowling Green, KY was found on March 12, 2014 and is rated as fair. It is not a great bathroom but once again just a little planning make it possible to get out healthy. The low-splash, lidded toilet and the single-handled faucet improve the overall health factor. It would be wise for guests to close the lid on the toilet, open the door before flushing and save hand washing for last for the most healthful exit.

This bathroom is at the same Bowling Green, KY hotel but is in the lobby near the front desk and was also photographed on March 12, 2014 and this one is rated as fair. It is one of the few restrooms to feature a low-splash, lidded toilet in a common area, which helps reduce the potential for virus getting out to nearby high-traffic areas—particularly eating areas. It does have a knob-actuated, inward-swinging door but does offer paper towels and two different small waste bins for convenient disposal of a hand barrier paper towel, if used.



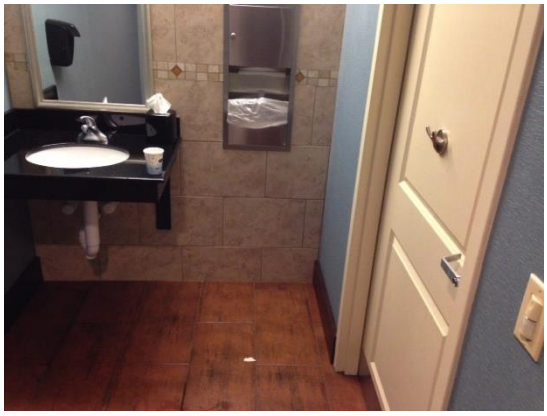
This bathroom is in a guestroom of a Memphis, TN hotel on March 13, 2014 and is scored good. It features the healthful design of the toilet area being behind a door separate from the sink area. Additionally, the faucet has a large, single handle that is very easy to use. The layout also shows how it is possible to store extra linens clear of the toilet by placing them under the sink clear of the any splash or cross contamination issues. It is plausible, though, due to the placement of extra towels near the knees that contamination could occur if someone standing at the sink had knelt down while sick or

came in contact with (knowingly or not) remnants of virus. However unlikely this scenario is, it is one of the many things a thoughtful design would avoid.

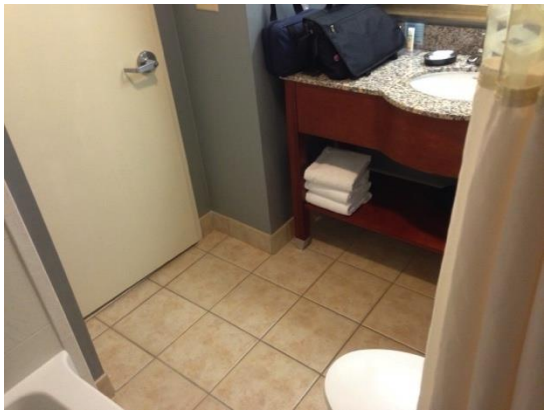

This lobby bathroom was found at the same Memphis, TN hotel as the guestroom bathroom also on March 13, 2014 and receives a score of fair. It does have high-splash toilets but stall partitions to limit spread of aerosolized contents. The faucet is easy to use with an elbow and paper towels are present for use as a hand barrier upon exit. The small trashcan under the paper towels is not ideal and poses a significant cross-contamination hazard and is also out of place for an easy discard of a barrier paper towel. The alternate trashcan, which is much larger, features a spring-loaded flapper making it difficult to discard paper towels without making hand contact.


This guestroom bathroom found in an Ashville, NC hotel on March 15th, 2014 is rated fair. The lidded, low-splash toilet and single-handled faucet should work to keep hygiene elevated but the inward swinging door works against it. Storage of surplus linens above the toilet is not a good practice. Overall, for a guestroom, it is not an awful design it will just require opening the door prior to hand washing but that is not on enough people's minds to be taken for granted.



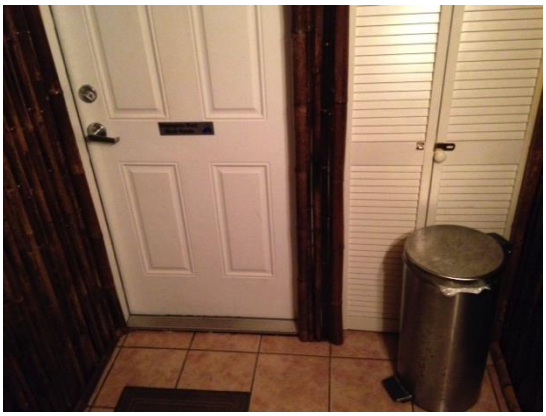
This bathroom was found in the lobby of the same Ashville, NC hotel on March 15th, 2014 and is rated good. This bathroom actually does just about everything right from the low-splash (non-lidded) toilet, to the single-handled faucet but the big hygienic difference is the inclusion of an outward swinging door and provision of paper towels. The presence of the latch and turning handle on the door are the only things standing in the way of healthful, hygienic exits for those that take the time to properly wash their hands.

This hotel guestroom bathroom is located in Edenton, NC and was photographed on March 17th, 2014 and it receives the score of fair. The low-splash, lidded toilet is as healthful as can be expected in a guestroom. The sink features a single, easy-to-use faucet but the lever is slightly undersized for easiest hands-free use. The inward-swinging door with a latched, turning knob would need to be opened before washing for a healthful exit but can be achieved with simple planning.



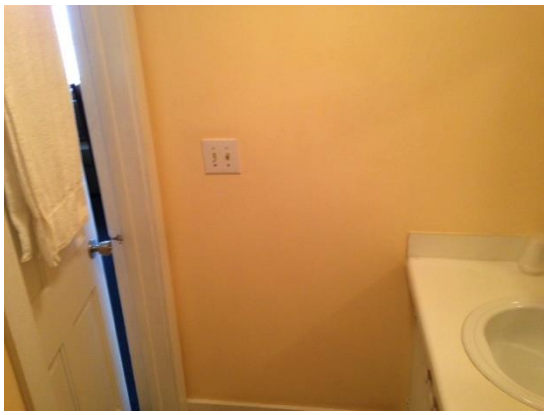
This guestroom bathroom was found in a Morehead City, NC hotel on March 19th, 2014 and is rated as fair. The toilet is a low-splash model and features a lid. The sink features an easy-to-use, single-handled faucet. The inward-swinging door has a latched knob but is easy to overcome in a guestroom. Once again, the small layout leads to placement of extra linens in the potential path of hand-washing drippings leaving them vulnerable to contamination in the event an occupant is actively shedding virus.

This hotel guestroom bathroom was found at an Augustine, FL hotel on March 21st, 2014 and is rated as fair. The toilet is a low-splash, lidded model but is in close proximity to linens intended for facial use. The sink area provides an easy-to-use, single-handled faucet and the door is an outward-swinging model, which is good but it is latched, detracting from healthful exit potential.



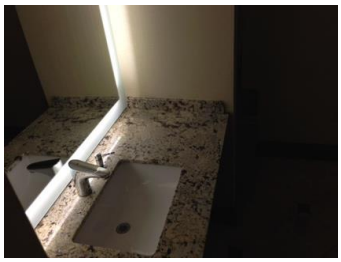
This bathroom was photographed in a Key West hotel in a common area near the pool on March 25th, 2014 and is rated as fair. The tight quarters are aided by the inclusion of a lidded, low-flush toilet. The faucet supplied is not conducive to healthful hand washing

due to the small, separate controls for hot and cold water that are difficult to shut off with an elbow. The outward-swinging door has a separate deadbolt for privacy and just adds an additional point of contact for viral contamination. This bathroom does include paper towels for barrier use but the lidded trashcan makes discarding the barrier more difficult.

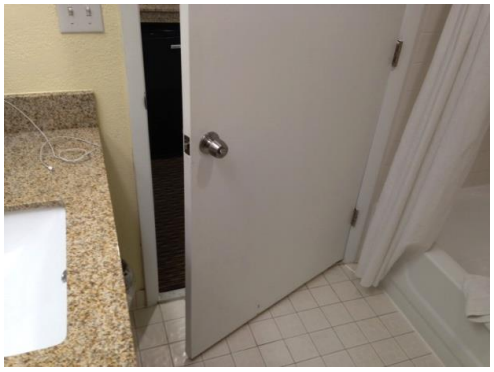


This bathroom is located at a Key West hotel in a guestroom and was photographed on March 25th, 2014 and is rated fair. It nearly scored good but the doorknob requires a full-handed grip to twist and eliminates the choice of elbow actuation for those attempting to keep hands clean following washing. The low-splash, lidded toilet is a benefit to healthfulness. The faucet has separate hot and cold controls on small handles.

This bathroom was photographed on March 27th, 2014 at a Las Vegas, NV hotel guestroom and is rated as good. The toilet and sink areas are divided into separate areas by a door. The toilet is a lidded, low-splash model located far from extra linens reducing the chances for inadvertent cross-contamination. The faucet has separate handles for hot and cold water but elbow actuation is possible. Extra linens are tucked underneath the sink and on the vanity top unwrapped drinking glasses were stored along with the provision of facial tissues. The latter two items should not be placed near the faucet as they increase the chances of poor hand-washing causing an infection by droplets splashing off poorly-washed hands getting on surfaces another user would be likely to put in their mouth or on their face.



This bathroom was photographed on March 27th, 2014 in the same Las Vegas, NV hotel but in the lobby area and is rated as fair. The mixed use of technology helps healthfulness at the sink but hinders it in the toilet. For peace of mind occupants may choose to use paper toilet seat barriers but in the partitioned stall, the high-splash toilet may mist them if it automatically flushes before they are ready to leave. The automatic faucets eliminate a contamination opportunity at the most important and are a good inclusion. The door, however, is a latchless, inward-swinging design and the inclusion of paper towels and a trashcan near the door makes barrier usage easy.



This hotel guestroom bathroom was photographed on March 26th, 2014 in Florida City, FL and is rated fair. The toilet is a low-splash, lidded model located right near the extra linen storage, which is not a good idea. The door is an inward-swinging model with a knob requiring a palm grip to twist to open and only good planning and timing would allow for a healthful exit following hand washing. The faucet is hardly worth mentioning as there are sufficient problems with design already but here a model with separate hot & cold controls was offered making things even worse for hygiene.

D) Minnesota Department of Health outbreak reports—contact author or the Minnesota Department of Health for up-to-date PDF report files (this research based on reports for 2010, 2011, 2012, 2013, and preliminary reports for 2014); identifying characteristics have been withheld here out of respect to the affected institutions; while this is a matter of public record a disclosure here unnecessarily tarnishes the reputation of institutions that have complied with the advice of regulatory agencies. Older reports are available at their website (16).

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